

Near-riparian vegetation of the Colorado River at Colorado Bend State Park and Regency, Texas.

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ABSTRACT

We analyzed the near-riparian zone along the Colorado River in the Lampasas Cut Plain (LCP) of Texas at Colorado Bend State Park (CBSP) as well as private property at Regency, Texas and described species composition and structure of vegetation. Both of these sites had not been grazed by cattle in decades and we compared it to Timberlake Biological Station (TBS), where grazing has occurred for decades, but ended in 2021 as well as creek side vegetation reported from the Blackland Prairie (BP). Our analysis was conducted to provide baseline knowledge on the natural vegetation of this near-riparian zone that has only been examined from Texas in the LCP ecoregion at TBS and the adjacent BP ecoregion. The near-riparian zone of the two sites in this investigation were different from each other with the state park site more similar to TBS and both being less diverse than similar ecosystems reported from the BP. At CBSP the near-riparian zone was comprised of three vegetational layers: 1) upper-canopy of trees including mainly cedar elm (*Ulmus crassifolia*) 2) under-canopy of the lianas saw greenbriar (*Smilax bona-nox*) and poison ivy (*Toxicodendron radicans*), the fern ally scouring-rush (*Equisetum hyemale*) as well as both annual and perennial grasses and forbs. Dominant grasses and sedges at CBSP included switch grass (*Panicum virgatum*), broad-leaf woodoats (*Chasmanthium latifolium*), and Emory's caric sedge (*Carex emoryi*). The dominant forb at CBSP was knotweed (*Polygonum* sp.). At Regency, the near-riparian zone was comprised of three vegetational layers: 1) upper-canopy of trees including mainly sugarberry (*Celtis laevigata*) 2) under-canopy of saw greenbriar (*Smilax bona-nox*) as well as both annual and perennial grasses and forbs. At Regency, the near-riparian was dominated by introduced Johnsongrass (*Sorghum halepense*) and Emory's caric sedge. The dominant forb at Regency was spiny-aster (*Chloracantha spinosa*). CBSP was richer, more even, and had higher Shannon-Weiner Diversity in its woody species but had a similar Shannon-Weiner Diversity value to Regency in their herbaceous species. The near-riparian region was about the same as the bottomland diversity at TBS and on the Bosque River, near Stephenville, Texas. Diversity was lower than that reported in riparian areas of the adjacent BP. The diversity, of these near-riparian sites being higher than bottomland forests from the region, likely reflects the dynamic nature of these ecosystems due to hydrological disturbance and the chance-events of dispersal and successful establishment of plants in this changing environment. Published online www.phytologia.org *Phytologia* 105(1): 1-14 (March 21, 2023). ISSN 030319430.

KEY WORDS: Near-riparian forest, Colorado River, Lampasas Cut Plain, Plant community ecology

Bottomland forests and their associated near-riparian zones are some of the most widely distributed, species-rich, and productive communities throughout southern regions of North America (Braun 1964;

Messina and Conner 1998; Baker et al. 2004). It has been estimated that over one-half of the bottomland forest ecosystem in Texas has been lost (Barry and Kroll 1999) and most, including the near-riparian area adjacent to the Colorado River in this investigation, have had their hydrology changed due to damming to form reservoirs (Texas Parks and Wildlife (TPWD) 2012). Because of these losses there is interest in restoration and preservation of riparian zones. However, little is known about community composition of the near-riparian zone in Texas, which is defined here as the narrow, dynamic area adjacent to the bottomland and beginning at the water's edge. This region is an extremely important buffer zone for the adjacent bottomland forest and has been shown to differ in species composition from the bottomland in East and North Central Texas (Nixon et al. 1991, 1977; Nixon and Raines 1976; Nelson et al. 2021).

Description of the natural vegetation is an important phase in understanding riparian areas. There has been limited description and vegetational analysis of such communities (TPWD 2012). Only one investigation at Timberlake Biological Station (TBS) (Nelson et al. 2021) in Texas has examined understory quantitatively in near-riparian zones of North Texas.

Other descriptive studies and subsequent qualitative reports of southern floodplain forests (Diamond et al. 1987; Meadows and Stanture 1997; Twedt and Best 2004; Lockhart and Kellum 2006; Twedt et al. 2010; Rosiere et al. 2013; Nelson et al. 2018) indicated the widespread sugarberry-elm-pecan forest type to be highly variable in its composition, especially where it is ecotonal to adjacent cover types. The general forest community as found in Texas was described variously as elm/sugarberry parks/woods (McMahan and Frye 1987), sugarberry-elm series (Diamond et al. 1987), sugarberry-elm floodplain forest (Bezanson 2000), and Edwards Plateau floodplain hardwood forest (Elliott 2013). By these conventions, Nelson et al. (2021) classified the near-riparian at TBS as green ash-elm.

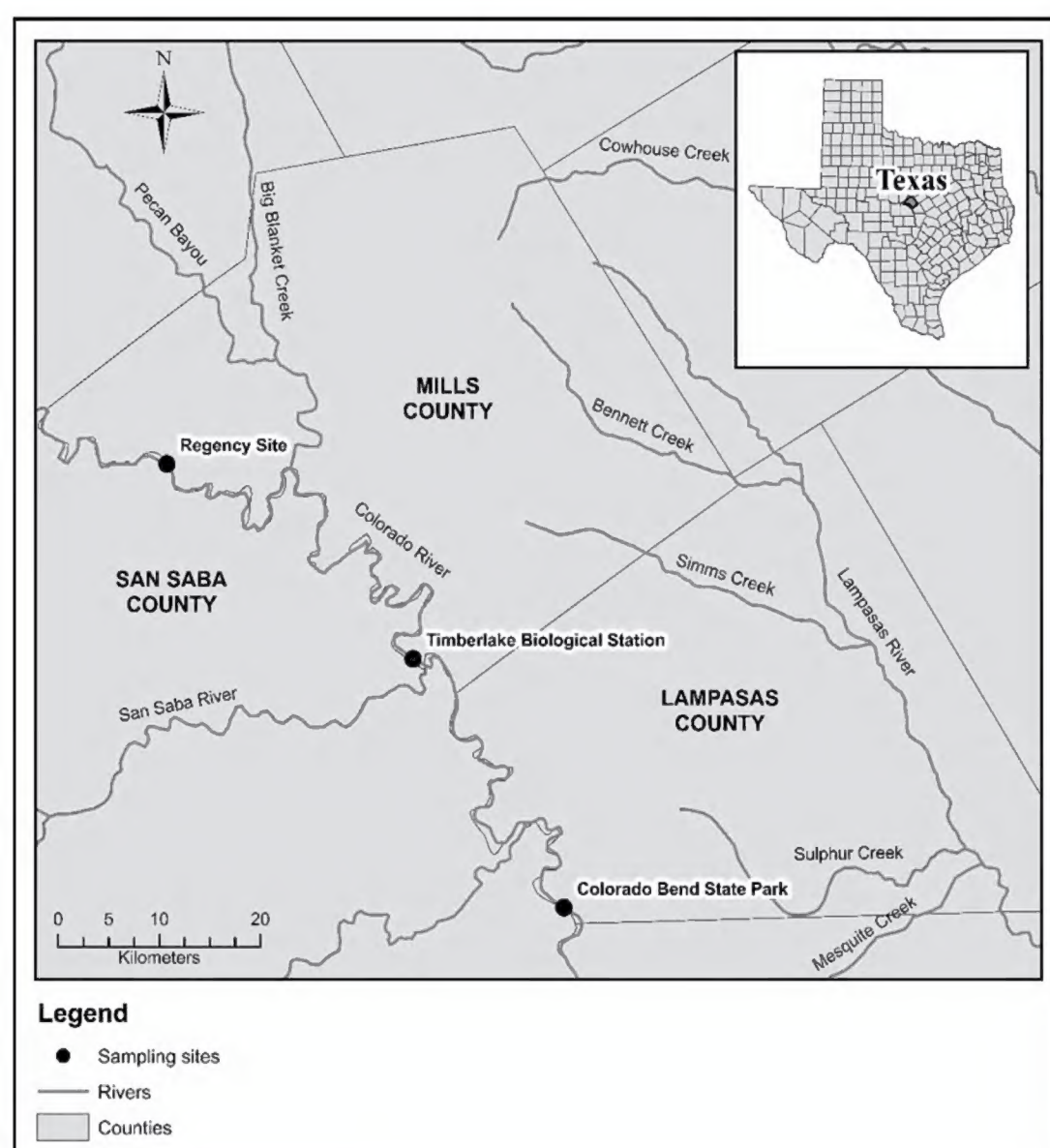
Descriptions of understories of woodlands in eastern and southern forest regions of the United States commonly have been in conjunction with soil surveys under leadership of the Natural Resources Conservation Service (NRCS; (Soil Conservation Service 1967, 1976; NRCS 2003) and, more recently, river authorities (Jones-Lewey 2016). In an attempt to generally describe riparian areas across the state, the Nueces River Authority (NRA) produced a field guide, which included some of the common vegetation found in Texas riparian areas (Jones-Lewey 2016). Descriptions of grazeable woodlands are currently written as forest land ecological sites (NRCS 2003). Forest land ecological site descriptions need greater detail regarding forest vegetation, including that of the understory. Likewise, classification of natural communities such as forest alliances and series (Diamond et al. 1987; McMahan and Frye 1987; Bezanson 2000, Hoagland 2000) as well as the field guide by the NRA (Jones-Lewey 2016) have been largely qualitative with limited quantitative information provided.

Rosiore et al. (2013) and Nelson et al. (2018) described bottomland forests, which aligned with the description of southern floodplain forests described above. Lonard et al. (1997; 1998; 1999; 2000; 2001; 2004), Lonard and Judd (2002), Everitt et al. (1999; 2002), and Zhang et al. (1998) documented riparian vegetation including the near-riparian for the Rio Grande in South Texas, but species composition of the subtropical Rio Grande was too different for comparison to this temperate-region investigation. To our knowledge, the only publications that mentions near-riparian vegetation in temperate North Texas is Nixon et al. (1991) and Nelson et al. 2021). Nixon et al. (1991) investigated creekside forest along Spring Creek, north of Garland, Texas. They found that sugarberry, elms (*Ulmus* spp.), and ashes (*Fraxinus* spp.) were the most important tree species along the creek side. The most prevalent shrubs and small trees were roughleaf dogwood (*Cornus drummondii*), rusty blackhaw (*Viburnum rufidulum*), Carolina buckthorn (*Rhamnus caroliniana*), and eastern red cedar (*Juniperus virginianum*). River grape (*Vitis riparia*), poison-

ivy (*Toxicodendron radicans*), and Virginia creeper (*Parthenocissus quinquefolia*) were the most common lianas at the site. Shannon-Weiner diversity was 3.40 and richness was 32. Nelson et al. (2021) reported three vegetational layers of the Colorado River at TBS: 1) upper canopy of trees including mainly green ash (*Fraxinus pennsylvanica*) and about equal amounts of cedar elm (*Ulmus crassifolia*) and American elm (*U. americana*) 2) under canopy of the liana saw greenbrier (*Smilax bona-nox*) as well as both annual and perennial grasses and forbs. Green ash was the dominant tree and saw greenbrier and Virginia Creeper (*Parthenocissus quinquefolia*) were the only two lianas. Dominant grasses and sedges included Canada wildrye (*Elymus canadensis*), switch grass (*Panicum virgatum*) and Emory's caric sedge (*Carex emoryi*). The dominant forb was spiny-aster (*Chloracantha spinosa*). Shannon-Weiner diversity was 1.12 (woody) and richness (woody) was 5.

We conducted this investigation to provide descriptions and analyses of near-riparian forests of the Colorado River in the LCP (Diggs et al. 1999) at places on the river that were less grazed than TBS (Nelson et al. 2021) and more arid than that of the BP (Nixon et al. 1991). Currently there is a need for quantitative data of this forest vegetation, which is lacking for much of Texas (Diamond et al. 1987) and because of ongoing classification and ground-truthing of natural plant communities (Elliott 2013), as well as riparian reclamation and restoration projects.

MATERIALS AND METHODS



The Regency study area, located within the small town of Regency, Texas in southwestern Mills County, is found within the LCP ecoregion (Diggs et al. 1999) and Cross Timbers and Prairies vegetational area (Correll and Johnston 1979; Fig. 1). CBSP is located west of Lampasas in San Saba and Lampasas counties on the former sites of the Gorman and Lemons ranches above Lake Buchanan. Texas Parks and Wildlife Department (TPWD; 2022) purchased part of the park in 1984, and the rest in 1987, which resulted in livestock grazing cessation. The 5,328.3-acre park opened in 1987 with campgrounds and hiking trails (TPWD 2022).

Figure 1. Map showing the Colorado River with study sites labeled, Texas. Inset shows the location of the counties in Texas.

The Colorado River in Texas, which borders the two research sites (Fig. 1) is the longest river confined to the state, beginning in the Caprock Escarpment near Lamesa, Texas, and flows to the Gulf of Mexico at Matagorda Bay (Crisp 2012). Both sites are downstream from Lake O. H. Ivie, which was constructed 27

years ago at the confluence of the Concho and Colorado rivers (Williams 2016), about 145 km south of Abilene, Texas. We sampled vegetation from October, 2016 to April, 2017 using nonpermanent plots, which have been shown to yield few statistically significant differences from permanent plots in riparian vegetation monitoring (Laine et al. 2013).

We used the step-point method (Evans and Love 1957; Bonham 1989) to determine composition of herbaceous and seedling (< 1.0 cm in diameter) species from the near-riparian zone. Plants were sampled randomly with a sharp-pointed pipe and total and relative numbers of hits were recorded. We sampled a total of 956 points in CBSP and 536 in Regency. We sampled the near-riparian within six rectangular quadrants each of which was 2.0 by 50 m with the longest dimension parallel to the river bank as described by Ford and Van Auken (1982) and Wood and Wood (1988, 1989). The six areas were sampled on the east (Regency) and south (CBSP) sides of the Colorado River by wading or using canoes to access sites. Fewer points were sampled at Regency because it was less diverse and our sampling curve flattened and we took fewer samples.

For woody vegetation, we used the same six rectangular quadrants, 2.0 by 50 m to sample all woody species greater than 1.0 cm in diameter. We identified the woody species and measured diameter at breast height (dbh). The dbh was used to calculate basal area. We calculated density (plants/ha), dominance (basal area/ha), and relative-importance values as described by Ford and Van Auken (1982) and Wood and Wood (1988, 1989). Shannon-Weiner diversity, richness, and evenness were calculated according to formulas in Ludwig and Reynolds (1988).

Species of plants were identified and classified using Diggs et al. (1999), which also served as the reference for common and scientific names for this investigation. We deposited voucher specimens in the herbarium (TAC) at Tarleton State University in Stephenville, Texas. Using classifications for the Great Plains ecoregion, wetland indicator status for plants was obtained from Lichvar et al. (2016).

RESULTS

Scientific names are included in Tables 1 and 2 and common names are used for the results and discussion sections of this article. There were 10 woody species greater than 1.0 cm in diameter at CBSP and seven at Regency, all of which were native. For all woody species >1.0 cm in diameter, cedar elm had the highest relative-importance value and greatest dominance as well as the highest relative cover >1.0 cm of any species of tree at CBSP, while sugarberry had the same statistics at Regency. After these two dominants the most common trees, >1.0 cm overall, were green ash at CBSP and American elm at Regency (Table 1). All of the tree species mentioned above had a wetland indicator status of facultative (Table 1). Honey mesquite and western soapberry were facultative upland species and black willow (*Salix nigra*) at both sites was facultative wetland and Regency had common buttonbush (*Cephalanthus occidentalis*), which is classified as an obligate wetland species (Table 1).

There was a total of four species of lianas and five shrubs sampled at CBSP and only three lianas and one shrub (common buttonbush) at Regency. All of the liana and shrub species had a wetland indicator status of facultative or facultative upland with the exception of common buttonbush at Regency, which was an obligate wetland species. There were a number of regenerating tree species that were less than 1.0 cm in diameter at both sites. There were two introduced, woody species sampled, which included, Chinaberry and white mulberry (Table 2). Of the herbaceous species and fern ally, 87.5% were native and 12.5% were introduced (Table 2). Native perennial grasses comprised much of the herbaceous vegetation in the near-riparian zone and were dominated by native switchgrass at both sites, however introduced Johnsongrass was common at Regency. Two forbs were introduced but not common with a native knotweed most

common at CBSP and spiny aster more abundant at Regency (Table 2). Hemlock and scouring-rush at CBSP were facultative wetland species; whereas rattlebush and spiny-aster were facultative wetland species at Regency (Table 2). Saw-grass and Emory's caric sedge were obligate wetland species at CBSP, whereas American water-willow, water speedwell, and Emory's caric sedge was obligates at Regency (Table 2). Both sites had similar amounts of bare ground (Table 2). When comparing ecoregions, diversity was higher for the BP ecoregion (Table 3). CBSP was richer, more even, and had higher Shannon-Weiner Diversity in its woody species but had a similar Shannon-Weiner Diversity value to Regency in their herbaceous species (Table 3). The near-riparian region from both sites was about the same as the bottomland diversity at TBS and on the Bosque River, near Stephenville, Texas (Table 3).

Table 1. Density, dominance, and relative importance values (IV) for woody vegetation greater than 1.0 cm diameter breast height of near-riparian zone of Colorado River, Texas at Colorado Bend State Park (CBSP) and Regency, Texas. Wetland classification (Lichvar et al. 2016) is provided for taxa identified to species after the scientific name.

CBSP

Common name (Scientific name)	Wetland classification	Density (plants/ha)	Dominance (m ² /ha)	IV (%)
American elm (<i>Ulmus americana</i>)	Facultative	37.1	24.0	3.9
Black willow (<i>Salix nigra</i>)	Facultative wetland	0.1	1.3	0.1
Cedar elm (<i>U. crassifolia</i>)	Facultative	1036.8	222.7	70.7
Green ash (<i>Fraxinus pennsylvanica</i>)	Facultative	204.9	45.3	14.1
Honey mesquite (<i>Prosopis glandulosa</i>)	Facultative upland	0.002	1.3	0.1
Pecan (<i>Carya illinoensis</i>)	Facultative	0.01	2.7	0.2
Prickly-pear (<i>Opuntia</i> sp.)		16.8	2.7	1.1
Sugarberry (<i>Celtis laevigata</i> var. <i>laevigata</i>)	Facultative	14.9	25.3	2.9
Texas persimmon (<i>Diospyros texana</i>)	Not listed in Lichvar et al. (2016)	0.1	14.7	1.2
Western soapberry (<i>Sapindus saponaria</i> var. <i>drummondii</i>)	Facultative upland	10.8	46.7	4.5

Regency, Texas

Common name (Scientific name)	Wetland classification	Density (plants/ha)	Dominance (m ² /ha)	IV (%)
American elm (<i>Ulmus americana</i>)	Facultative	93.3	4.5	5.5
Black willow (<i>Salix nigra</i>)	Facultative wetland	13.3	2.9	1.1
Cedar elm (<i>U. crassifolia</i>)	Facultative	13.3	0.002	0.7
Common buttonbush (<i>Cephalanthus occidentalis</i>)	Obligate	13.3	0.001	0.7
Pecan (<i>Carya illinoensis</i>)	Facultative	80	4.7	4.8
Sugarberry (<i>Celtis laevigata</i> var. <i>laevigata</i>)	Facultative	746.7	323.4	86.5
Western soapberry (<i>Sapindus saponaria</i> var. <i>drummondii</i>)	Facultative upland	13.3	0.2	0.7

Table 2. Species composition as determined by step-point method herbaceous and woody plants (below 1.0 cm diameter) of the near-riparian zone of Colorado River, Texas at Colorado Bend State Park (CBSP) and Regency, Texas. An asterisk indicates an introduced species. Vegetation categories and their totals are in italics. Wetland classification (Lichvar et al. 2016) is provided after the scientific name.

Common name (Scientific name)	Wetland classification	#hits (%) CBSP	#hits (%) Regency
<i>Grasses</i>			
Barley (<i>Hordeum</i> sp.)		0.1	0
*Bermuda grass (<i>Cynodon dactylon</i>)	Facultative upland	0.3	1.9
Broad-leaf woodoats (<i>Chasmanthium latifolium</i>)	Facultative upland	2.4	3.4
Canada wildrye (<i>Elymus canadensis</i>)	Facultative upland	0.3	3.9
Hall's panic (<i>Panicum hallii</i> var. <i>hallii</i>)	Facultative upland	0	0.6
*Japanese brome (<i>Bromus japonicus</i>)	Not listed in Lichvar et al. (2016)	0.6	0.2
*Johnsongrass (<i>Sorghum halepense</i>)	Facultative upland	1.7	19.0
Silver bluestem (<i>Bothriochloa laguroides</i> subsp. <i>torreyana</i>)	Not listed in Lichvar et al. (2016)	0	0.6
Southwestern bristle grass (<i>Setaria scheelei</i>)	Not listed in Lichvar et al. (2016)	0	0.2
Switch grass (<i>Panicum virgatum</i>)	Facultative	3.1	0.7
<i>Total Grasses</i>		8.5	30.5
<i>Grasslike</i>			
Flat sedge (<i>Cyperus</i> sp.)		0	2.4
Saw-grass (<i>Cladium mariscus</i> subsp. <i>jamaicense</i>)	Obligate	0.9	0
Sedge (<i>Carex</i> sp.)		0.5	0
Emory's caric sedge (<i>Carex emoryi</i>)	Obligate	27.4	10.3
<i>Total Grasslike</i>		28.8	12.7
<i>Forbs</i>			
American water-willow (<i>Justicia americana</i>)	Obligate	0	0.7
Aster (<i>Aster</i> sp.)		0	2.6
Boneset (<i>Eupatorium</i> sp.)		0.3	0
Buttercup (<i>Ranunculus</i> sp.)		0.1	0
Catchweed bedstraw (<i>Galium aparine</i>)	Facultative upland	0.1	0
Cocklebur (<i>Xanthium strumarium</i> var. <i>canadense</i>)	Facultative	0	0.4
Creeping ladies' sorrel (<i>Oxalis corniculata</i>)	Facultative upland	0.4	0.2
Frostweed (<i>Verbesina virginica</i>)	Facultative upland	0.1	0
Giant goldenrod (<i>Solidago gigantea</i>)	Facultative	0	0.4
*Hemlock (<i>Conium maculatum</i>)	Facultative wetland	0.6	0
Horseherb (<i>Calypocarpus vialis</i>)	Facultative	0.1	0
Knotweed (<i>Polygonum</i> sp.)		1.6	0
Late Eupatorium (<i>Eupatorium serotinum</i>)	Facultative	0	2.4
Mustard unknown (Brassicaceae)		0	0.7
Narrow-leaf sumpweed (<i>Iva angustifolia</i>)	Not listed in Lichvar et al. (2016)	0	0.4
Old-man's-beard (<i>Clematis drummondii</i>)	Upland	0.3	0
Pigeonberry (<i>Rivina humilis</i>)	Facultative	0	0.7
*Prickly sow-thistle (<i>Sonchus asper</i>)	Facultative	0.2	0
Rattlebush (<i>Sesbania drummondii</i>)	Facultative wetland	0	0.2
Shade betony (<i>Stachys crenata</i>)	Facultative	0.4	0
Spiny-aster (<i>Chloracantha spinosa</i>)	Facultative wetland	0	6.7
Texas thistle (<i>Cirsium texanum</i>)	Not listed in Lichvar et al. (2016)	0.2	0
Vetch (<i>Vicia</i> sp.)		0.1	0
Water speedwell (<i>Veronica anagakkis-aquatica</i>)	Obligate	0.5	0
Wild chervil (<i>Chaerophyllum tainturieri</i>)	Facultative	0.7	0
<i>Total Forbs</i>		5.7	15.4

Table 2 continued

Fern ally

Scouring-rush (<i>Equisetum hyemale</i> subsp. <i>affine</i>)	Facultative wetland	6.4	0
Total Fern ally		6.4	0

Shrubs/lianas

Gum bumelia (<i>Sideroxylon lanuginosum</i>)	Facultative upland	0.4	0
Mustang grape (<i>Vitis mustangensis</i>)	Not listed in Lichvar et al. (2016)	0.1	0
Poison ivy (<i>Toxicodendron radicans</i>)	Facultative upland	4.4	0.9
Roughleaf dogwood (<i>Cornus drummondii</i>)	Facultative	1.2	0
Rusty blackhaw (<i>Viburnum rufidulum</i>)	Facultative upland	0.7	0
Saw Greenbriar (<i>Smilax bona-nox</i>)	Facultative upland	5.8	2.2
Southern dewberry (<i>Rubus trivialis</i>)	Facultative upland	2.3	0
Virginia creeper (<i>Parthenocissus quinquefolia</i>)	Facultative upland	1.5	1.1
Whitebrush (<i>Aloysia gratissima</i>)	Not listed in Lichvar et al. (2016)	0.1	0
Total Shrubs		16.5	4.2

Trees

American elm (<i>Ulmus americana</i>)	Facultative	0.3	1.5
Black willow (<i>Salix nigra</i>)	Facultative wetland	0.3	0.2
Cedar elm (<i>Ulmus crassifolia</i>)	Facultative	2.3	0.6
*Chinaberry (<i>Melia azedarach</i>)	Facultative upland	0.1	0
Green ash (<i>Fraxinus pennsylvanica</i>)	Facultative	0.7	0
Red mulberry (<i>Morus rubra</i>)	Facultative upland	0.1	0
Sugarberry (<i>Celtis laevigata</i> var. <i>laevigata</i>)	Facultative	0.4	3.2
Western soapberry (<i>Sapindus saponaria</i> var. <i>drummondii</i>)	Facultative upland	0	0.4
*White mulberry (<i>Morus alba</i>)	Facultative upland	0	0.2
Total Trees		4.2	6.1

Bare ground**29.6 31.2****DISCUSSION**

Quantitative data for woody and herbaceous vegetation in near riparian zones of the LCP, including nonnative species, were provided. At CBSP the near-riparian zone was comprised of three vegetational layers: 1) upper-canopy of trees including mainly cedar elm 2) under-canopy of the lianas saw greenbriar and poison ivy, the fern ally scouring-rush as well as both annual and perennial grasses and forbs (Tables 1 and 2). Dominant grasses and sedges at CBSP included switch grass, broad-leaf woodoats, and Emory's caric sedge. The dominant forb at CBSP was a knotweed (Table 2). At Regency, the near-riparian zone was comprised of three vegetational layers: 1) upper-canopy of trees including mainly sugarberry 2) under-canopy of saw greenbriar as well as both annual and perennial grasses and forbs (Tables 1 and 2). At Regency, the near-riparian was dominated by introduced Johnsongrass and Emory's caric sedge and the dominant forb at Regency was spiny-aster (Table 2).

The near-riparian community had a depauperate species composition when compared to a creekside community in the BP ecoregion (Nixon et al. 1991). Nixon et al. (1991) found that sugarberry, elms, and ashes were the most important tree species in the near-riparian of Spring Creek in the BP. At TBS, green ash dominated the near riparian instead of the more even distribution of several trees reported for Spring Creek. At these two sites, cedar elm and sugarberry were dominants (Table 1). Sugarberry is reported to be

frequently browsed by ungulates and its fruits are an important food source for many birds (Linex 2014). Linex (2014) and Jones-Lewey (2016) stated that elms are the most widespread and important riparian trees in Texas, which help protect river banks during flooding. Linex (2014) indicated that cedar elm is frequently browsed by cattle and deer. We sampled nine species of tree seedlings at both sites, which was greater than that reported from the near-riparian at TBS (Nelson et al. 2021). Lianas and small shrubs were also more abundant than that found at TBS (Nelson et al. 2021). Based on these data, we hypothesize that cattle grazing removes tree seedlings and understory lianas and shrubs from the near-riparian on the Colorado River at TBS. Recent publications on livestock grazing indicate there may be some successful management strategies but cattle having free range into the areas, as was done at TBS is detrimental (Jones et al. 2022; Deroose et al. 2020; Kaweck et al. 2018). Unmanaged cattle grazing is likely the primary factor causing decreased understory diversity at TBS. Lack of cattle grazing for decades has likely increased understory diversity at CBSP and Regency.

Table 3. Richness, Evenness, and Shannon-Weiner Diversity in the Texas Colorado River near-riparian compared to that of other sites reported in the literature. The abbreviation “NR” indicates the statistic was not reported.

	Near-riparian CBSP	Near Riparian Regency, Texas	Near-riparian at Timberlake Biological Station	Adjacent Bottomland (Nelson et al. 2018)	Bosque River Bottomland (Rosiere et al. 2013)	Spring Creek Bottomland (Nixon et al. 1991)	Spring Creek Near- Riparian (Nixon et al. 1991)
Woody Richness > 1.0 cm	10	7	5	13	17	32	29
Richness < 1.0 cm	42	31	22	40	30	NR	NR
Woody Evenness > 1.0 cm	0.83	0.45	0.70	0.59	0.77	NR	NR
Evenness < 1.0 cm	0.67	0.76	0.70	0.66	0.66	NR	NR
Woody > 1.0 cm Shannon-Weiner Diversity	1.91	0.87	1.12	1.51	2.18	3.60	3.40
< 1.0 cm Shannon-Weiner Diversity	2.52	2.62	2.16	2.42	2.26	NR	NR

Green ash has relatively extensive coverage across East, Central, and South Texas and is highly tolerant of disturbance; growing not only along the streamside but on extremely steep channel slopes (Duke 2015). It was the second most common species at CBSP but was not sampled at the Regency site (Table 1). Jones-Lewey (2016) indicated that green ash is important in protecting banks during floods and one of the most common species of ash in the eastern one-third of Texas. Linex (2014) added that it provided fair browse value for deer and was one of the first trees to grow back in abandoned fields adjacent to or replacing bottomlands. Its absence from the Regency study site could be due to modified hydrology after river damming as well as other factors like dispersal or herbivory.

TPWD (2012) and Nelle (2015) listed Chinaberry (*Melia azedarach*), Chinese tallow (*Sapium sebiferum*), Japanese honeysuckle (*Lonicera japonica*), and salt cedar (*Tamarix* spp.) as nonnative species that could be problematic in bottomlands associated with the Colorado River in the Lampasas Cut Plain. TPWD also listed tree of heaven (*Ailanthus altissima*) as an invasive tree. Anderson (2006) listed Chinaberry and chaste tree as non-native species found in the river corridor near Austin and Bastrop, Texas. Only two species of nonnative woody plants, Chinaberry and chaste tree, were observed at the study sites but these were not sampled as adult plants, because they were not common. Chaste tree likely escaped from yards near the river. Chinaberry was a rapid-growing species along the San Antonio River (Bush and Van Auken 1984) and a species associated with sugarberry and cedar elm (Van Auken and Bush 1985). Richardson et al. (2007) explained that rivers were very susceptible to invasion by alien plants because hydrologic dynamics and frequent disturbances of streams make them especially effective for dispersal of plant propagules. Bush and Van Auken (1984) commented that Chinaberry along with sugarberry and native colonizing tree species likely become established following flooding. Chinaberry may be considered invasive and spreads rapidly along riparian areas (Jones-Lewey 2016). To date, it is only a minor component of the woody vegetation at this study sites.

Previous investigations (Bush and Van Auken 1984; Diamond et al. 1987; McMahan and Frye 1987; Bezanson 2000), generally placed less emphasis on shrubs and provided little data and analysis of herbaceous layers of bottomland-hardwood forests. By contrast, this investigation and Nelson et al. (2021) included the understory of the forest sampled in the near-riparian. Density and dispersion of trees combined with the small numbers of lianas and relatively low number of seedlings and saplings of trees formed a canopy sparse enough for development of an herbaceous understory dominated by native perennial grasses along the Colorado River at all three sites. Herbaceous layers of the forest along the near-riparian of the Colorado River at CBSP and Regency were similar to those reported for bottomland forests of the West Cross Timbers in Texas (Rosiere et al. 2013; Nelson et al. 2018) and TBS with the exception of dominance by switchgrass at both CBSP and Regency and high amounts of Johnsongrass at Regency. Nixon et al. (1991) reported more shrubs for a creek forest in the BP ecoregion, but most of these shrubs, other than lianas, were absent from the forest adjacent to the Colorado River at TBS (Nelson et al. 2021) but more were present at CBSP and Regency. This could be due to extensive grazing and browsing by herbivores (whitetail, beaver, cattle), which may remove shrub seedlings at TBS (Nelson et al. 2021).

Switchgrass was the most common native grass in the understory at both sites and was common at TBS (Nelson et al. 2021). Canada wildrye and broadleaf wood oats were dominants in a West Cross Timbers bottomland (Rosiere et al. 2013) and broadleaf woodoats is common on the floodplains along rivers in the Texas Hill Country (Gustafson 2015), whereas Canada wildrye was the most common grass in the understory at TBS in the floodplain forest (Nelson et al. 2018). They are viewed as dominants in late-seral to climax vegetation along streams and floodplains throughout much of Oklahoma (Tyrl et al. 2008) and Texas (Gould 1975). However, it appears from our spatially-limited investigation of the near-riparian zone, that Switchgrass is more common there and helps to stabilize the dynamic erosional nature of the near-riparian (Linex 2014). The most common sedge at CBSP and Regency as well as TBS (Nelson et al. 2021) was Emory's caric sedge, which is an obligate wetland species, and may indicate negative changes in hydrology when reduced or absent (Jones-Lewey 2016).

TPWD (2012) listed Bermuda grass (*Cynodon dactylon*), as a nonnative species that could be problematic in the Colorado River in the Lampasas Cut Plain but did not mention Johnsongrass, which is also problematic (Nelson, personal observation). There were two introduced grasses with Bermuda grass being the most common on the Colorado River and Japanese brome being less common at TBS (Nelson et al. 2021), however, both were infrequent in the near-riparian region. The most common introduced grass

in the near-riparian zone at CBSP and Regency was Johnsongrass, which occurs in large colonies on the uplands associated with these sites and likely spread into the near-riparian zone.

Spiny-aster was a facultative wetland species that was the most common forb in the near-riparian at TBS (Nelson et al. 2021) and at Regency. Its rhizomes help stabilize river banks and young plants are eaten by deer and cattle (Linex 2014). Knotweed was the most common at CBSP and although it was vegetative and we could not identify it to species, it is often associated with wetland areas. The only introduced forbs in the near-riparian of the Colorado River at CBSP and Regency were prickly sow-thistle and hemlock, which were both sampled from CBSP.

Nelson et al. (2021) concluded that herbivory is likely affecting regeneration of woody species and perennial herbs in the near-riparian of the Colorado River at TBS. Beaver are not common in the Hill Country (Gustafson 2015) but appear to be common and detrimental at this study site on the Colorado River in the LCP at TBS (Nelson et al. 2021), as well as at Regency, which had less tree diversity and dominance than CBSP.

Improperly managed white-tailed deer can cause significant damage to riparian vegetation by their consumption of forbs and shrubs as browse (Nelle 2015). White-tailed deer were observed in the Colorado River bottomland and near-riparian frequently. Nelson Dickinson and Van Auken (2016) reported that large vertebrate herbivores, mainly white-tailed deer, significantly affected the survival and density of juvenile bigtooth maple (*Acer grandidentatum*) at Lost Maples State Park in Texas. Cogger et al. (2014) tabulated that at bottomland forest restoration sites along the Upper Mississippi River and its tributaries, white-tailed deer browsed 46% of tree seedlings and preferred American elm over green ash, which could be a reason that green ash is more dominant in the near-riparian of the Colorado River.

Feral pigs are considered detrimental to Texas ecosystems (TPWD 2012) and livestock grazing has affected almost all riparian areas in the state and is considered one of the most significant disturbances affecting them (Nelle 2015). Removal of cattle from riparian areas in the Northwestern Great Basin resulted in dramatically increased coverage in riparian vegetation (Batchelor et al. 2015; Jones et al. 2022). One instance of beneficial impacts reported for cattle grazing was that ephemeral wetland diversity increased with cattle grazing, which removed exotic grasses from the wetlands (Marty 2005). In the stretch of the near-riparian of the Colorado River sampled, there were few to no ephemeral wetlands and our data suggested that herbivory by deer, and beaver activity may have impeded regeneration of trees and shrubs at Regency (Table 2). CBSP had deer browse but we saw no evidence of beaver activity in the areas we sampled.

Another possibility for reduced regeneration of woody species and herbaceous perennials is low flow hydrology. Low flow hydrology during droughts and flood flow events have been documented in changing riparian vegetation (Hardy and Davis 2015). Most river ecosystems have been disrupted by dams, which separate and isolate remnant floodplains changing riparian biodiversity (Johnson 2002). This part of the Colorado River was most changed by the construction of a dam near the confluence of the Colorado and Concho rivers, which became Lake O. H. Ivie (Crisp 2012; Williams 2016). The Colorado River near-riparian was not dominated by wetland species. Alldredge and Moore (2014) reported this to be true of the Sabine River in East Texas as well. Riparian areas should contain a mix of obligate wetland, facultative wetland, and facultative species depending on water availability and it is important that riparian areas have species from the facultative group to provide stability due to hydrological change (Asher et al. 2015). The Colorado River near-riparian zone at CBSP and Regency had a few facultative wetland and obligate species but was not dominated by wetland species, being mostly facultative upland and upland species with the only dominant obligate and facultative wetland species present in the Colorado River being Emory's caric

sedge and spiny aster, respectively at Regency for both and at CBSP for the former. Based on these dominants and a few other wetland species (Tables 1 and 2), CBSP and Regency have a more stable hydrology than TBS (Nelson et al. 2021).

Diversity at CBSP and TBS on the Colorado River were different from that reported at TBS (Nelson et al. 2021) and from a near-riparian zone in the BP (Nixon et al. 1991). CBSP was richer, more even, and had higher Shannon-Weiner Diversity in its woody species but had a similar Shannon-Weiner Diversity value to Regency in their herbaceous species. The near-riparian region was about the same as the bottomland diversity at TBS (Nelson et al. 2021) and on the Bosque River, near Stephenville, Texas (Rosiere et al. 2013). Species diversity was lower than that reported in riparian areas of the adjacent BP (Nixon et al. 1991), which receives much more precipitation than that of the LCP ecoregion. The diversity of these near-riparian sites being higher than bottomland forests from the region likely reflects the dynamic nature of these ecosystems due to hydrological disturbance and the chance-events of dispersal and successful establishment of plants in this changing environment.

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Rudbeckia grandiflora* var. *alismifolia* (Asteraceae) in Oklahoma*John Michael Kelley**

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ABSTRACT

Rudbeckia grandiflora var. *alismifolia* is reported for the first time from Oklahoma. This report is based on a specimen collected in 1999 from Red Slough Wildlife Management in the extreme southeastern part of the state. The Oklahoma Natural Heritage Inventory intends to track the taxon as historical pending surveys. Published online www.phytologia.org *Phytologia* 105(1): 15-17 (March 21, 2023). ISSN 030319430.

KEYWORDS: Coneflower, Prairie, Flatwoods.

Rudbeckia grandiflora (Sweet) A.P. de Candolle var. *alismifolia* (Torrey & A. Gray), or largeflower coneflower, is an asteraceous herb reaching about 1 m in height, from a woody caudex, with drooping yellow rays, and with the lower stems and leaves glabrous, scabrous, or with ascending hairs less than 0.5 mm long (Urbatsch and Cox 2006). It inhabits high-quality pinelands and prairies in the Gulf Coastal Plain (Small 1933; Weakley 2022). In 2020, I distinguished this variety from var. *grandiflora* in Louisiana after a review of digitized herbarium specimens and site visits (Kelley 2020). My ongoing work delineating the extent of these taxa recently uncovered a specimen of var. *alismifolia* from Red Slough Wildlife Management Area in McCurtain County, Oklahoma (Fig. 1). The specimen, collected in 1999, was examined for me by Tiana Rehman at BRIT and a duplicate was examined by Amy Buthod at OKL, who also digitized for me a second collection from the same area by a different collector. These are apparently the first records of this taxon for Oklahoma (USDA, NRCS 2023; Weakley 2022). The variety will be treated as historical since the collections were made more than 20 years ago.

The collectors found largeflower coneflower in “wet forests”. This terminology belies the strong grassland affinities; other species collected from this locality are obvious heliophytes. Associates typical of open flatwoods and prairies and collected from the same locality included *Asclepias hirtella*, *Carex brevior*, *Helenium flexuosum*, *Liatris pycnostachya*, *Linum curtissii*, *Mimosa nuttallii*, *Neptunia lutea*, *Packera tomentosa*, *Physostegia angustifolia*, *Tradescantia occidentalis*, and *Vernonia missurica*.

It is well established that a series of grasslands formerly existed along the Red River drainage from southeast Oklahoma to northwest Louisiana, but little evidence of these prairies remains (Flores 1984; MacRoberts et al. 1997). Grassland remnants on mounded, acid loams in northwest Louisiana regularly include var. *alismifolia* in association with most of the aforementioned associates (pers. obs.). The Red Slough WMA still contains examples of this habitat, and var. *alismifolia* should be sought in these areas in mid-summer.

Voucher specimen: **Oklahoma. McCurtain County:** Red Slough WMA, Habitat: wet forest, Abundance: infrequent, 19 July 1999, N. McCarty (with F. Johnson) RSGS353 (OKL) (Fig 1).



Figure 1. Record specimen.

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***Picea pungens* (Pinaceae) branch and trunk wood essential oil profile comparison from cultivated trees in northern Idaho (USA)**

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ABSTRACT

Picea pungens is an essential oil-bearing plant in the Pinaceae family. The essential oil of *P. pungens* was produced through steam distillation and examined to identify and compare the volatile profiles of both the branch and trunk wood. The resulting samples ($n = 12$) were analyzed by GC/MS and GC/FID. Prominent (defined as avg. $\geq 2\%$) volatile compounds from *P. pungens* branch include (averages) α -pinene (29.0%), camphene (12.3%), β -pinene (6.6%), myrcene (5.5%), δ -3-carene (7.9%), limonene (20.2%), camphor (4.2%), and bornyl acetate (2.3%). Prominent (defined as avg. $\geq 2\%$) volatile compounds from trunk wood include (averages) α -pinene (60.3%), camphene (2.0%), β -pinene (16.2%), myrcene (3.0), δ -3-carene (3.1%), and limonene (8.3%). Comparing the branch and trunk wood essential oil profiles, they are similar, with six prominent volatile compounds in common. However, the different parts of the tree have specific compounds unique to that portion of the tree and could be used for determining quality of commercial essential oil and for chemotaxonomic identification. Published online www.phytologia.org *Phytologia* 105(1): 18-24 (March 21, 2023). ISSN 030319430.

KEY WORDS: aromatic profile, branch, chemotaxonomy, essential oil, *Picea pungens*, trunk

Picea pungens Engelm. (blue spruce) is a conifer in the Pinaceae family with a native range primarily in the western United States and southern Rocky Mountains, with populations growing between 1800 m to 3000 m elevation (Flora of North America 1993; World Flora Online 2023). Trees in their native habitat typically grow to a height of 50 m, with trunk diameters of 1.5 m, prickly and stiff and bluish green needles that spread radially (Fig. 1) (Auders & Spicer 1990; Bailey 1951; Flora of North America 1993). *Picea pungens* is commonly cultivated and distributed under various names of cultivars. They are primarily valued for ornamental purposes due to their pyramidal, symmetrical shape, unique color, and are not desirable as timber due to wood knots. (Auders & Spicer 1990; Welch 1979).



Figure 1. Botanical illustration showing portion of *Picea pungens* limb with mature seed cone. Illustrated by Zach Nielsen, Utah Valley University (Orem, UT, USA).

Previous research on *P. pungens* has shown the stem portion of the tree to be primarily composed of the following compounds and relative abundances: α -pinene (41.0%), camphene (2.4%), β -pinene (22.7%), sabinene (2.5%), δ -3-carene (24.7%), limonene (4.7%) (Lewinsohn et al. 1991). Other research that differentiated foliage and xylem/bark chemical profiles showed that camphene (12.6%), myrcene (9.8%), limonene (30.9%), camphor (11.2%) and bornyl acetate (14.0%) all had higher concentrations in the foliage than in the xylem/bark. In contrast, the same study showed that α -pinene (71.4%, xylem), β -pinene (20.0%, xylem), sabinene (2.4%, xylem), δ -3-carene (22.2%, bark) were more abundant in the xylem/bark (Hanover 1992). Other researchers confirmed that primary constituents of *P. pungens* included α -pinene, camphene, sabinene, β -pinene, myrcene, δ -3-carene, and limonene throughout the tree (Ott et al. 2021; Raber et al. 2021).

Previous research on evergreen species in the Pinaceae family has shown that trunk wood essential oil often contains unique compounds that can be used for chemotaxonomic investigations (Poulson et al. 2020; Ruggles et al. 2022). The current study establishes essential oil profiles for samples extracted from the branch and trunk wood of *P. pungens* and provides integrative tools for determining quality of commercial essential oil and for chemotaxonomic investigations.

MATERIALS AND METHODS

Picea pungens branch and trunk plant material were collected from privately owned cultivated tree farmland in Bonner County, Idaho, USA (48°34'41.3" N 116°26'16.1" W; 696 m elevation). The plant material was collected on the following dates with the corresponding average daily temperatures (for simplicity and consistency, essential oil samples are referred to by a letter, A-L) (historical weather data from ncei.noaa.gov): (A/G: March 24, 2021, 5.3°C), (B/H: April 19, 2021, 11.7°C), (C/I: July 8, 2021, 23.9°C), (D/J: September 20, 2021, 10.8°C), (E/K: November 8, 2021, 3.9°C), (F/L: December 7, 2021, -6.1°C). A total of eighteen trees (avg. age of eight years – determined by dendrochronology) were cut approximately halfway up the trunk utilizing the stump culture technique (Wunderlich 2020). Both the branches and the trunk material were used for this research (Fig. 2). The branches include limb material and needles. The trunk material includes the inner and outer bark, cambium, sapwood, and heartwood sections. Representative voucher samples used for identification are held in the University of Idaho Stillinger Herbarium in Moscow, ID, USA, and the Consortium of Pacific Northwest Herbaria in Seattle, WA, USA.



Figure 2. Botanical illustration showing (from left to right) *Picea pungens* tree (approximate age 8 years – young tree without seed cones), chipped branch plant material, and chipped trunk plant material. Illustrated by Zach Nielsen, Utah Valley University (Orem, UT, USA).

The plant material was prepared for distillation as follows (Figure 1). The limbs were removed flush against the trunks and separated. The branch material included all limb material including needles. The trunk material was the main tree trunk with no needles or limb material. The different plant materials were chipped with a woodchipper, blended, and stored in an airtight container at -20 ± 2 °C until steam distilled. Six separate steam distillations were performed on the prepared chips for each portion, resulting in a total of twelve distillations for this study. The distillations were conducted in a 12-L food grade stainless steel distillation chamber (Albrigi Luigi S.R.L., Italy) with approximately 2.5 liters of water added to the chamber. Steam was passed through suspended chips for two hours after pass-over and the essential oil was separated from hydrosol using a cooling condenser and collected in an analytical graduated cylinder. The essential oil was stored in a sealed amber glass bottle until analysis.

Essential oil samples were analyzed, and volatile compounds identified, by GC/MS using an Agilent 7890B GC/5977B MSD (Agilent Technologies, Santa Clara, CA, USA) and Agilent J&W DB-5, 0.25 mm \times 60 m, 0.25 μ m film thickness, fused silica capillary column. Operating conditions: 0.1 μ L of sample (20% soln. for essential oils in ethanol), 100:1 split ratio, initial oven temp. of 40 °C with an initial hold time of 5 min., oven ramp rate of 4.5 °C per min. to 310 °C with a hold time of 5 min. The electron ionization energy was 70 eV, scan range 35–650 amu, scan rate 2.4 scans per sec., source temp. 230 °C, and quadrupole temp. 150 °C. Volatile compounds were identified using the Adams volatile oil library (Adams 2007) using Chemstation library search in conjunction with retention indices. Note that limonene/ β -phellandrene elutes as single peaks. Their amounts were determined by the ratio of masses 68 and 79 (limonene), 77 and 93 (β -phellandrene). Volatile compounds were quantified and are reported as a relative area percent by GC/FID using an Agilent 7890B GC and Agilent J&W DB-5, 0.25 mm \times 60 m, 0.25 μ m film thickness, fused silica capillary column. Operating conditions: 0.1 μ L of sample (20% soln. for essential oils in ethanol, 1% for reference compounds in ethanol, 0.1% soln. for C7–C30 alkanes in hexane), 25:1 split ratio, initial oven temp. of 40 °C with an initial hold time of 2 min., oven ramp rate of 3.0 °C per min. to 250 °C with a hold time of 3 min. Essential oil samples were analyzed in triplicate by GC/FID to ensure repeatability (standard deviation < 1 for all compounds). Compounds were identified using retention indices coupled with retention time data of reference compounds (MilliporeSigma, Sigma-Aldrich, St. Louis, MS, USA).

RESULTS AND DISCUSSION

The essential oil profile of both branch and trunk plant material of *Picea pungens* were determined by GC/MS and GC/FID (Table 1). Prominent (defined as avg. $\geq 2\%$) volatile compounds from *P. pungens* branch include (averages) α -pinene (29.0%), camphene (12.3%), β -pinene (6.6%), myrcene (5.5%), δ -3-carene (7.9%), limonene (20.2%), camphor (4.2%), and bornyl acetate (2.3%). Prominent (defined as avg. $\geq 2\%$) volatile compounds from trunk wood include (averages) α -pinene (60.3%), camphene (2.0%), β -pinene (16.2%), myrcene (3.0), δ -3-carene (3.1%), and limonene (8.3%). These types of similarities seen in essential oil profiles of different plant parts of the same species may be a defining quality of plants of the Pinaceae family (Poulson et al. 2020; Ruggles et al. 2022).

In comparison, the essential oil profile of both the branches and trunk wood of *P. pungens* are similar, sharing six prominent (defined as avg. $\geq 2\%$) volatile compounds in common, including α -pinene, camphene, β -pinene, myrcene, δ -3-carene, and limonene. However, the values (averages) differ greatly with relative percent differences (Table 2) ranging from 58.8% (myrcene) to 144.1% (camphene). The relative abundance of camphene, myrcene, δ -3-carene, limonene, and bornyl acetate were greater in the branch material, whereas α -pinene, sabinene, and β -pinene were greater in the trunk. The following compounds (averages) were found in both plant parts but detected in higher relative abundance in the branches, compared to the trunk: 1,8-cineole (1.6%, 0.1%), camphor (4.2%, 0.4%), camphene hydrate (1.3%, 0.1%), and borneol (1.0%, 0.1%), respectively. Several minor compounds differentiate the branch and trunk essential oil profiles from each other. Hexanal, (3Z)-hexenol, n-hexanol, ethyl hexanoate, 3-

methyl-3-butenyl-3-methyl-butanoate, isoborneol, ethyl octanoate, carvone, piperitone, and α -muurolene were all found in the branches, but not in the trunk. Whereas α -pinene oxide, trans-pinocamphone, cryptone, β -elemene, and germacrene D were all detected in the trunk, but not in the branches. Characteristic compounds such as those have been used to identify and differentiate plant species on trees burnt in wildfires when traditional taxonomic methods could not be used (Wilson et al. 2021). Additionally, both the presence and abundance of unique compounds can be used for determination of the quality of a commercial essential oil product (i.e., provide insight into the harvest details and distillation method of an aromatic plant) (Wilson et al. 2021).

Table 1. Aromatic profile of *Picea pungens* essential oil from both branch and trunk material. Compounds not detected in a sample are denoted as not detected (ND) and those with values less than 0.1% are denoted as traces (t). Compounds less than 1.0% that were unidentified are not included. KI is the Kovat's Index using a linear calculation on the DB-5 column (Adams 2007). Relative area percent is determined by GC-FID. All essential oil samples were analyzed in triplicate to ensure repeatability (SD <1).

Compound	KI	Branch						Trunk					
		A	B	C	D	E	F	G	H	I	J	K	L
hexanal	801	nd	t	t	t	t	nd	nd	nd	nd	nd	nd	nd
(3Z)-hexenol	850	0.1	t	t	0.2	0.1	nd	nd	nd	nd	nd	nd	nd
n-hexanol	863	t	nd	nd	t	t	nd	nd	nd	nd	nd	nd	nd
santene	884	0.6	0.2	0.3	0.2	0.3	0.3	0.2	0.1	0.1	0.1	0.3	0.1
tricyclene	921	1.6	1.1	1.7	1.7	1.4	1.8	0.6	0.6	0.6	0.7	0.6	0.5
α -thujene	924	0.2	0.2	0.1	0.2	0.1	0.3	0.3	0.2	0.2	0.3	0.2	0.3
α -pinene	932	24.2	43.6	22.1	32.3	24.1	27.5	50.3	71.5	51.0	65.6	63.5	59.9
camphene	946	12.5	8.0	14.4	13.3	11.5	14.4	2.6	2.3	1.8	2.0	2.0	1.5
thuja-2,4(10)-diene	953	t	t	t	t	t	t	t	0.1	t	t	0.1	t
sabinene	969	1.2	1.1	0.9	0.8	0.5	0.8	2.3	1.2	1.2	1.0	0.9	1.3
β -pinene	974	8.5	4.4	8.3	5.7	5.3	7.6	19.0	6.4	25.6	13.2	14.9	18.1
myrcene	988	7.0	4.7	6.8	6.2	5.3	3.0	3.7	2.1	2.6	2.7	3.8	2.9
ethyl hexanoate	997	t	0.1	t	nd	0.1	t	nd	nd	nd	nd	nd	nd
α -phellandrene	1002	t	t	t	t	t	t	t	t	t	t	t	t
δ -3-carene	1008	9.3	10.4	8.0	8.4	3.8	7.7	5.2	2.8	2.5	3.5	3.1	1.3
α -terpinene	1014	t	t	t	t	t	t	t	t	t	t	t	nd
p-cymene	1020	t	t	t	t	0.1	t	t	t	t	t	t	t
o-cymene	1022	0.5	0.5	0.5	0.6	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.4
limonene	1024	20.7	17.1	24.8	16.2	20.9	21.3	10.3	7.5	8.8	7.0	7.2	8.7
β -phellandrene	1025	0.4	0.2	0.3	0.4	0.1	0.6	0.8	0.3	0.4	0.4	0.4	0.2
1,8-cineole	1026	1.8	1.0	2.4	1.3	1.1	1.7	0.3	0.2	0.1	0.1	t	0.1
(Z)- β -ocimene	1032	t	0.1	t	t	t	t	0.1	0.1	t	0.1	0.1	0.1
(E)- β -ocimene	1044	0.1	0.1	t	t	t	0.1	t	t	t	t	t	nd
γ -terpinene	1054	t	t	t	t	t	t	t	0.1	t	t	t	t
p-mentha-2,4(8)-diene	1085	t	t	t	t	t	t	t	t	t	t	t	t
terpinolene	1086	0.4	0.4	0.4	0.2	0.3	0.5	0.3	0.4	0.1	0.2	0.2	0.1
linalool	1095	t	t	t	t	0.1	t	t	0.1	t	t	t	t
α -pinene oxide	1099	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	t	t
3-methyl-3-butenyl-3-methyl-butanoate	1112	nd	t	nd	nd	0.1	t	nd	nd	nd	nd	nd	nd
endo-fenchol	1114	t	t	t	t	0.1	t	t	t	t	t	t	t
α -campholenal	1122	0.1	t	0.1	0.1	0.1	t	t	t	0.1	t	t	0.1
trans-pinocarveol	1135	t	t	t	0.1	0.2	0.1	0.1	0.1	0.2	0.1	0.1	0.2
camphor	1141	3.1	2.5	2.3	4.2	8.1	4.8	0.7	0.6	0.3	0.2	0.2	0.3
camphene hydrate	1145	1.1	0.7	0.8	1.4	2.2	1.7	0.2	0.2	0.1	0.1	t	0.1
isoborneol	1155	t	t	0.1	0.1	0.1	t	nd	nd	nd	nd	nd	nd
trans-pinocamphone	1158	nd	nd	nd	nd	nd	nd	0.1	t	0.1	t	t	0.1
borneol	1165	0.9	0.4	0.7	1.0	1.9	1.0	0.2	0.2	0.2	0.1	0.1	0.1
cis-pinocamphone	1172	t	nd	t	nd	nd	nd	t	t	t	t	t	t

Compound	KI	Branch						Trunk					
		A	B	C	D	E	F	G	H	I	J	K	L
terpinen-4-ol	1174	0.2	0.2	0.2	0.3	0.5	0.2	0.1	0.2	0.2	0.1	0.1	0.2
p-cymen-8-ol	1179	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.2
cryptone	1183	nd	nd	nd	nd	nd	nd	nd	nd	0.1	t	nd	0.1
α -terpineol	1186	0.3	0.2	0.3	0.3	0.6	0.3	0.1	0.1	0.1	0.1	0.1	0.1
methyl chavicol	1195	0.1	t	0.1	0.1	0.2	0.1	0.1	0.1	0.2	0.1	0.1	0.2
ethyl octanoate	1196	t	t	t	t	t	nd	nd	nd	nd	nd	nd	nd
verbenone	1204	t	t	nd	t	0.1	t	t	t	0.1	t	t	0.1
trans-carveol	1215	t	t	t	t	0.2	t	t	t	t	t	t	0.1
citronellol	1223	0.1	0.1	0.1	0.1	0.5	0.1	t	t	0.1	t	t	0.1
thymol methyl ether	1232	t	t	t	t	t	t	t	t	t	t	t	t
carvone	1239	nd	t	t	0.1	0.2	t	nd	nd	nd	nd	nd	nd
piperitone	1249	t	nd	0.1	t	t	t	nd	nd	nd	nd	nd	nd
bornyl acetate	1284	2.6	0.9	2.8	1.9	3.4	2.3	0.7	0.9	1.4	0.8	0.4	1.0
citronellyl acetate	1350	t	nd	nd	nd	nd	nd	nd	nd	nd	t	t	t
β -elemene	1389	nd	nd	nd	nd	nd	nd	t	t	0.1	t	t	t
(E)-caryophyllene	1417	t	t	t	t	t	t	t	t	t	t	t	t
germacrene D	1480	nd	nd	nd	nd	nd	nd	nd	t	nd	t	t	nd
α -muurolene	1500	nd	nd	t	t	t	t	nd	nd	nd	nd	nd	nd
cubebol	1514	nd	nd	0.1	0.1	t	0.1	t	t	t	t	t	t
δ -cadinene	1522	nd	t	t	0.1	t	t	t	t	t	t	0.1	t
cembrene	1937	nd	t	t	t	t	t	t	t	t	t	t	t

Table 2. The relative area % of prominent (defined as avg. $\geq 2\%$) compounds in *Picea pungens* essential oil, averaged across all samples. The relative percent difference (RPD) is provided.

Shared Prominent Compounds	Branches (avg.)	Trunk (avg.)	RPD
α -pinene	29.0	60.3	70.1
camphene	12.3	2.0	144.1
β -pinene	6.6	16.2	84.2
myrcene	5.5	3.0	58.8
δ -3-carene	7.9	3.1	87.3
limonene	20.2	8.3	83.5

The plant material was harvested throughout the year (dates ranging from March to December) in temperatures varying from -6.1°C to 23.9°C . While relative abundance of volatile compounds vary from sample to sample, this does not appear to be greatly influenced by the season or temperature (Fig. 3 & 4). This could allow for commercial production of *P. pungens* essential oil throughout growing and dormant seasons, while maintaining a relatively consistent product.

CONCLUSIONS

The methods used in this study have previously been used by these and other researchers. While the approach is not novel, the findings pertaining to this species are new to this field of science.

Both the compounds in common and the compounds unique to each plant part observed in this study provide a foundation for future investigations in both quality assurance of commercial production of blue spruce essential oil and for chemotaxonomic investigations. Future research performed on larger populations of blue spruce and including both cultivated and wildcrafted samples from various regions will provide more insight on these topics.

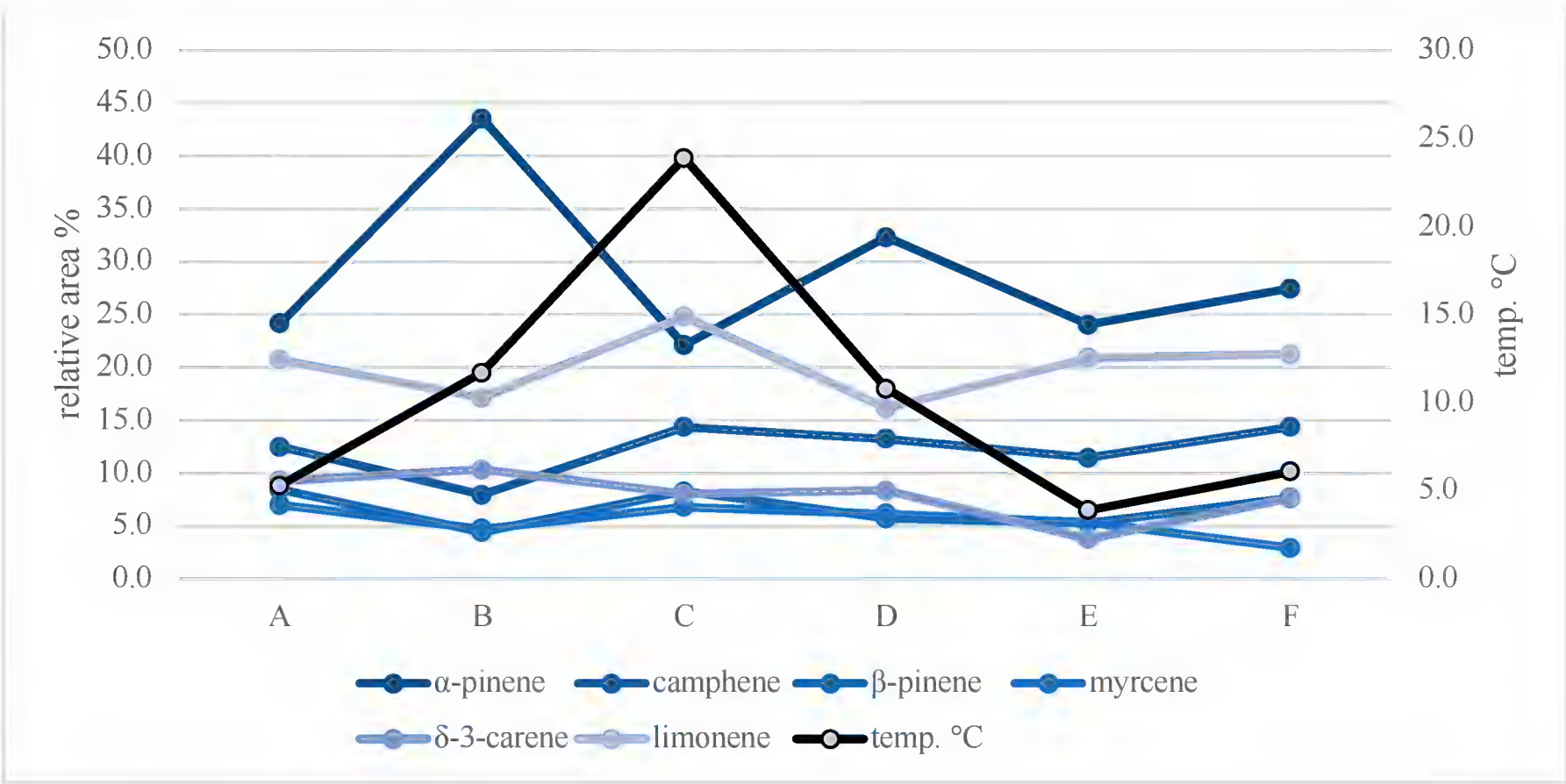


Figure 3. Chart showing relationship between relative area % (Y-axis) of volatile compounds, prominent (defined as $\geq 2\%$) compound names (X-axis), and temperature °C (Z-axis) in branch essential oil samples (A-F).

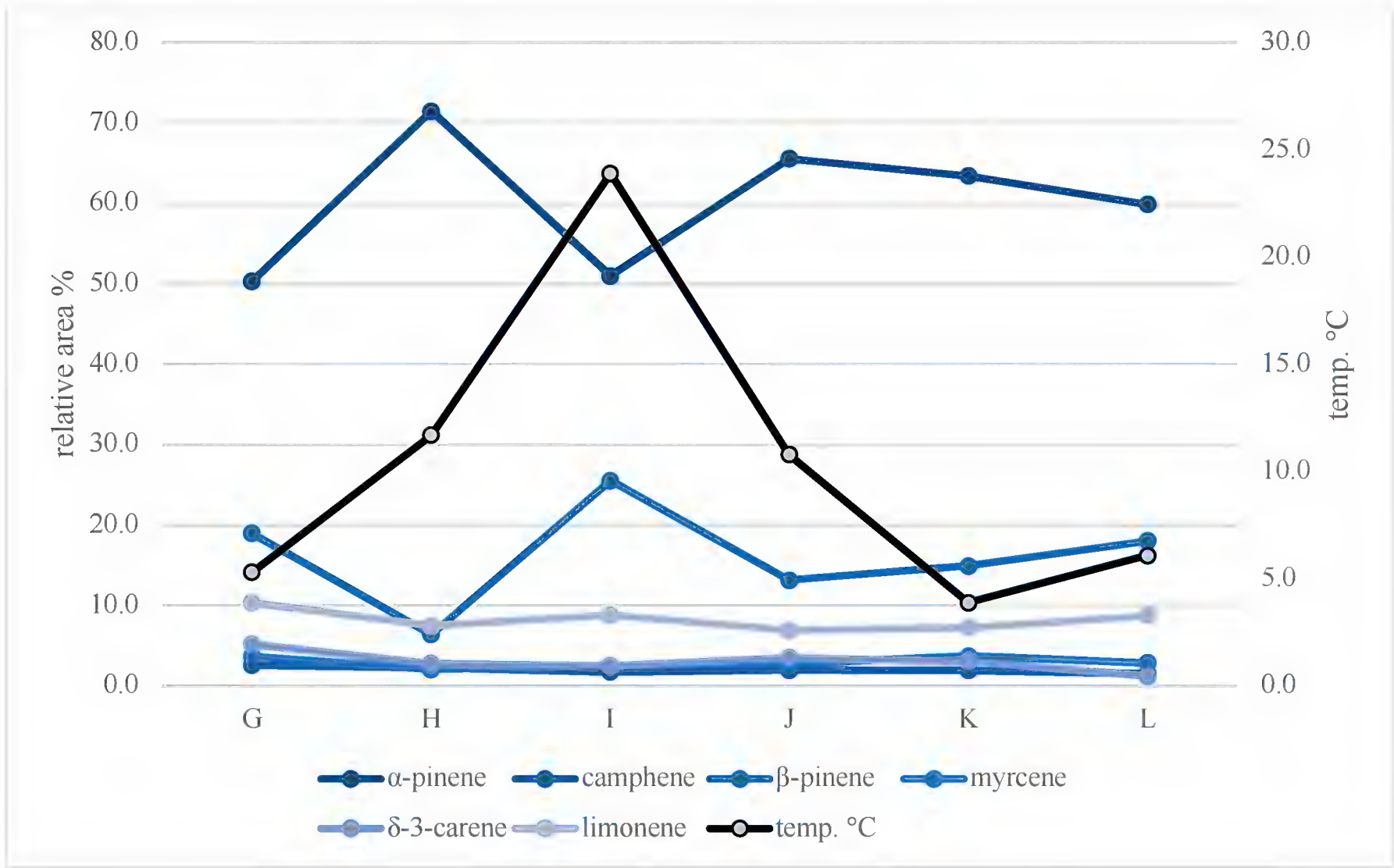


Figure 4. Chart showing relationship between relative area % (Y-axis) of volatile compounds, prominent (defined as $\geq 2\%$) compound names (X-axis), and temperature °C (Z-axis) in trunk essential oil samples (G-L).

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Penstemon albidus* (Plantaginaceae) in the Lampasas Cut Plain Ecoregion of Texas*Allan D. Nelson**Department of Biological Sciences, Tarleton State University, Stephenville, TX 76402
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ABSTRACT

We analyzed the distribution of *Penstemon albidus* Nutt. (Plantaginaceae) and found it did not occur in the Lampasas Cut Plain of Texas (LCP) as reported by The Biota of North America (BONAP) based on herbarium specimens from the LCP. Herbarium specimens from the Texas Oklahoma Regional Consortia of Herbaria (TORCH) and fieldwork on the plant were used to show that specimens were misidentified. Because of its similarity to the Central Texas endemic *P. guadalupensis*, we have observed many misidentifications based on images on the Internet, especially when leaf pubescence and/or corolla and leaf sizes cannot be closely examined or measured. Our work confirms *P. albidus* does not occur in the Lampasas Cut Plain. Published online www.phytologia.org *Phytologia* 105(2): 25-28 (June 21, 2023). ISSN 030319430.

KEY WORDS: *Penstemon albidus*, Lampasas Cut Plain, White penstemon, Floristics

The type specimen of *Penstemon albidus* was collected in 1811 by Thomas Nuttall and described in 1817 (Nuttall 1818). Until 1828, plants in *Penstemon* were sometimes classified as *Chelone*, which occurred here, but was resolved by Keck (1938) when he transferred the species from *Chelone* to *Penstemon*. *Penstemon* is a large genus that has been divided into subgenera and sections. Based on pollen sac characteristics, it has been placed in the subgenus *Penstemon* and the section *Cristati* by (Freeman 2019). Within the section *Cristati*, it has white petal lobes or white, rarely tinged with pink to lavender petal lobes, funnellform corollas subtended by a fused calyx with lobes that are glandular-pubescent (Freeman 2019). Flowers are in inflorescences with axes that are densely glandular-pubescent (Freeman 2019). The androecium has included stamens with opposite, explanate pollen sacs and the gynoecium has a glabrous pistil (Freeman 2019). Leaves are glabrate or puberulent to scabrous with basal and proximal leaves that are mostly 7-18 mm wide with rare extremes of 4-20 mm width (Freeman 2019). Blades are oblanceolate or obovate to lanceolate (Freeman 2019).

Penstemon albidus is commonly known as white-flower beardtongue and is a widespread prairie species occurring in Canada and the USA (Freeman 2019). In the USA it occurs in Colorado, Iowa, Kansas, Minnesota, Montana, Nebraska, New Mexico, Oklahoma, North Dakota, South Dakota, Texas, and Wyoming. Freeman (2019) noted that *P. albidus* is remarkably uniform in its vegetative and floral characters throughout its range. In the southern portion of its range in Texas, it becomes difficult to distinguish from *P. guadalupensis* (Stanford 1976) and often only differs by a few mm in leaf length or scabrous pubescence. Another white-flowered specimen, *P. cobaea* has also been erroneously identified as *P. albidus*, but has much larger corollas and wider leaves (Correll and Johnston 1970; Stanford, 1976; Diggs et al. 1999; Freeman 2019). The plants bloom from April through July and rarely into September and are commonly found growing in silty, sandy loam, or gravelly soils from 300 to 1800 m in elevation (Freeman 2019). In Texas, its distribution was thought to be restricted to the Great Plains and northern

Texas (Correll and Johnston 1970) but was reported further south into the Lampasas Cut Plain in Comanche and Lampasas counties by The Biota of North America Program (BONAP; Figure 1).

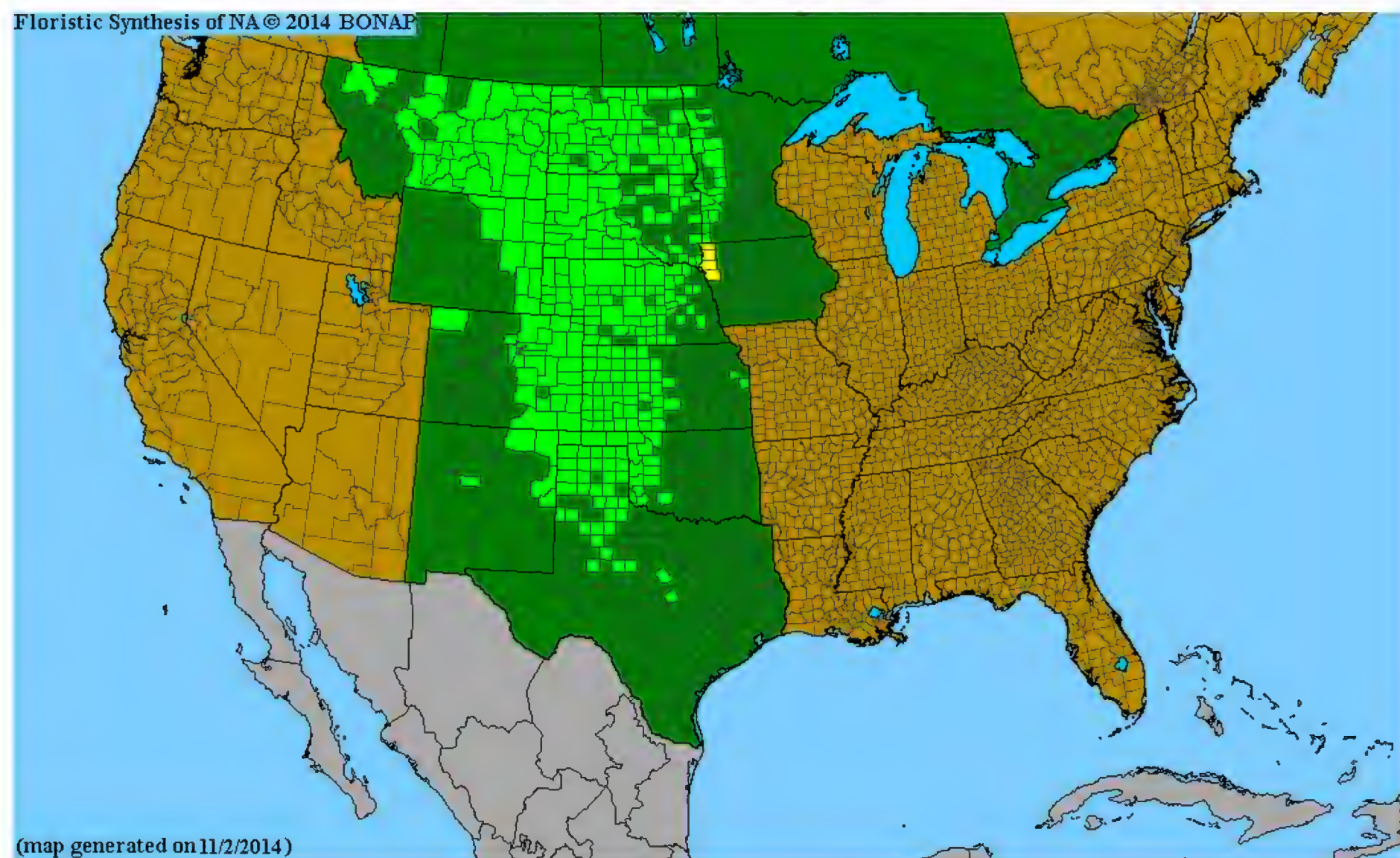


Figure 1. Map created in 2014 by The Biota of North America Program (BONAP) showing the state and county distribution of *Penstemon albidus*.

MATERIALS AND METHODS

Specimens from the Lampasas Cut Plain were examined in the field and located by a search of the Texas Oklahoma Regional Consortia of Herbaria (TORCH; Table 1). Specimens from TORCH that included digital images from the study region were examined to see that the basal leaves were less than 7.0 mm in width and that the corolla was 12-20 mm, which are important characters for identifying *P. albidus* to the species-level (Freeman 2019).

RESULTS AND DISCUSSION

We located five specimens at three herbaria in our search of the TORCH portal for counties in the LCP. Specimens from Burnet and Lampasas counties had corollas greater than 20 mm and should be annotated to *P. cobaea*. Specimens from Comanche County had basal leaves less than 7.0 mm and should be annotated to *P. guadalupensis*.

Though originally thought to occur in north Texas (Correll and Johnson 1970), Kartez (2015) mapped it further south in the Lampasas Cut Plain Ecoregion in Comanche and Lampasas counties. Our annotations of these herbarium specimens (Table 1) indicate that it does not occur in the LCP. Specimens from our search were likely used to make the BONAP map (Kartez 2015), which has resulted in confusion in identification, especially on Internet sites such as iNaturalist.

Table 1. Herbarium records from the Texas Oklahoma Regional Consortium of Herbaria for *P. albidus*

Herbarium, Acronym, and Number	Collector	Location	Date
San Angelo State University ASU-49346	B. Nelson	Texas, Burnet County, Road to Narun	5/10/1970
Texas A&M University, S.M. Tracy TAES-46591193	B. C. Tharp	Texas, Comanche County, Comanche	4/4/1928
Texas A&M University, S.M. Tracy TAES-183926	S. & G. Jones	Texas, Lampasas County, Lampasas	4/20/1988
University of Texas TEX-00025065	B. C. Tharp	Texas, Comanche County, Comanche	4/28/1934
University of Texas TEX=00351352	Mrs. J. F. Phipps	Texas, Comanche County, C[a]omyn, Texas	1/1/1931

Data from electronic sources on the Internet like iNaturalist that use images to identify taxa and then consider them research grade determinations, once at least two identifiers agree using those images, are likely to be mistaken, unless the image quality is sufficient for the many vegetative and reproductive microcharacters used in plant taxonomy. The algorithm used by iNaturalist for all identified taxa includes scoring each identification and using the ratio between the number of cumulative identifications for that taxon over the sum of the cumulative identifications (iNaturalist contributors, iNaturalist 2023). Then, for the identified taxa that have a score over 2/3 and at least 2 identifications, the iNaturalist algorithm uses the lowest ranked taxon as the name with the caveat that an observation can lose research grade status if the community votes it down from research grade using additional identifications and associated discussion (iNaturalist contributors, iNaturalist 2023). Many plant name determinations are not conducive to image searches and we predict that generic, species, and intraspecific taxa misidentifications are high in many cases. Naming by comparison using field guides, often arranged by flower color and of limited scope rarely provide research quality determinations. Unless images show characteristics used in dichotomous keys, Internet identification is just a rapid form of photographic comparisons and corolla color matching for photogenic species, which may have a place for an amateur, but should not be used in botany classes or research projects. Relying on community science websites for proper identification for various flora and fauna would not be academically sound for peer reviewed papers or research questions. Some of those sites do provide valuable data (Merrill et al. 2021), but using them as a sole mechanism for identifications or data sets may increase errors on research questions.

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Revision of the genus *Mariosousa* (Fabaceae, Mimosoideae) in the New World

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ABSTRACT

Originally referred to as the *Acacia coulteri* species group, the 14 members of genus *Mariosousa* are known from northern Central America and Mexico, with one species entering the southwestern United States. Detailed descriptions, habitat preferences, geographic ranges, and an exsiccatal list of all specimens examined by the authors are given. The species of this genus form a distinct group within the *Senegalia* grade (former *Acacia* series *Vulgares*), lacking prickles and spines and usually with persistent stipules. Published online www.phytologia.org *Phytologia* 105(2): 29-67 (June 21, 2023). ISSN 030319430.

KEY WORDS: *Acacia coulteri* group, list of exsiccatae, Fabaceae, Mexico, North and Central America, 14 taxa.

Numerous morphological and genetic studies support the view that the genus *Acacia* s.l. is polyphyletic, consisting of at least seven distinct groups of species (Seigler et al. 2017). Species of one of these groups were treated as *Senegalia* by Britton and Rose (1928). This group included some taxa now assigned to *Mariosousa*, *Parasenegalia* and *Pseudosenegalia*. Among other features, those of these three genera differ by the lack of prickles. *Mariosousa* is further distinguished by the order of development of seedling leaves: those in *Mariosousa* having the first two leaves pinnate followed by a bipinnate leaf, whereas in *Senegalia* the first three leaves are bipinnate or a singly pinnate leaf followed by two bipinnate leaves (Vassal 1972). A key that includes these four genera is provided in Miller et al. (2017). The *Acacia coulteri* species group in the New World was first recognized as distinct from the large genus *Acacia* s.l. by Jawad et al. (2000 [2001]). Later, Seigler et al. (2006a) named this new segregate genus *Mariosousa*, when they transferred 13 species of *Acacia* to that entity. An additional species, *M. gentryi*, was described by Seigler and Ebinger (2021).

Members of *Mariosousa* are erect shrubs or trees that lack prickles or spines, have persistent stipules, and have flowers in cylindrical spikes. Except for minor differences in flower size and pubescence, the flowers are quite similar, being 5-merous with tubular calyx and corolla, numerous separate stamens that usually possess anther glands, and a single short-stalked pistil. The 14 currently recognized species are distributed from Arizona and New Mexico (one species), south through Mexico (where all species of the

genus occur) to Belize, Guatemala, El Salvador, Honduras, Nicaragua and Costa Rica where three species occur, the most widespread being *M. centralis*.

In a recent nuclear phylogeny of the genus *Senegalia* (Koenen et al. 2020; Ringelberg et al. 2022), two well-supported clades correspond to: (1) a clade combining *Senegalia* sect. *Senegalia*, and *Senegalia* sect. *Monacantha* s.s. on one hand (clade A in Terra et al. 2017); and (2) *Senegalia* sect. *Monacantha* pro parte (p.p.) on the other hand (clade B in Terra et al. 2017). The two clades of *Senegalia* in this new phylogeny are congruent with the two main *Senegalia* clades found by Bouchenak-Khelladi et al. (2010), Kyalangalilwa et al. (2013), Boatwright et al. (2015) and Terra et al. (2017) that had more comprehensive taxon sampling. A third, moderately supported clade includes only the species *Mariosousa sericea* (M. Martens & Galeotii) Seigler & Ebinger, *Parasenegalia visco* (Lorentz ex Griseb.) Seigler & Ebinger and *Pseudosenegalia feddeana* (Harms) Seigler & Ebinger, interspersed between the two *Senegalia* clades. In marked contrast to the nuclear phylogeny, the two *Senegalia* sections are sister clades in the plastid phylogeny presented by Ringelberg et al. (2022), that supported the genus *Senegalia* as monophyletic based on plastid data alone. In summary, phylogenetic analyses indicate that the genus *Mariosousa* is closely related but distinct from the non-monophyletic genus *Senegalia* in a moderately supported clade comprised of *Senegalia*, *Mariosousa*, *Pseudosenegalia*, and *Parasenegalia* (Ringelberg et al. 2022; Terra et al. 2022). Phylogenetic analyses of plastid and/or nuclear sequence data support the genus *Mariosousa* as monophyletic (Seigler et al. 2006a, 2006b; Miller et al. 2017; Maslin et al. 2023).

In this publication, we include the accepted name and basionym for each species along with the citations and type information for all specimens examined. An accompanying list of exsiccatae (Appendix) includes the collector(s) and collecting number of each specimen. The complete citation and type information for synonyms of the majority of specimens we have examined are given in Jawad (2000 [2001]), Seigler et al. (2006a), and Seigler et al. (2023).

TAXONOMIC TREATMENT

Mariosousa Seigler & Ebinger in Seigler, Ebinger & J.T. Miller, Novon 16(3): 415-420. 2006a. **TYPE:** *Mariosousa coulteri* (Benth. in A. Gray) Seigler & Ebinger in Seigler et al., 2006a. [\equiv *Acacia coulteri* Benth. in A. Gray, 1852; \equiv *Senegalia coulteri* (Benth. in A. Gray) Britton & Rose, 1928].

Etymology: The genus *Mariosousa* honors Mario Sousa Sánchez (1940-2017), former Director of the Herbarium of the Instituto de Biología (MEXU), Universidad Autónoma de México (Rico Arce & Grether 2017).

Unarmed **shrubs** and **trees**; bark hard and fissured to sometimes papery and exfoliating; twigs usually not flexuous; short shoots mostly absent. **Leaves** alternate, bipinnately compound; stipules symmetrical, flattened, straight, herbaceous, narrowly triangular to linear, mostly persistent, and mostly not spinose; petioles usually adaxially grooved; petiolar glands small, solitary (sometimes absent); rachis usually adaxially grooved, with a small gland between the uppermost to rarely most pinna pairs; pinnae 1 to 30 pairs/leaf, mostly with numerous leaflets, commonly 4 to 65 pairs/pinna; leaflets mostly less than 10 mm long, opposite, linear to oblong to elliptic, base oblique, and often truncate on one side. **Inflorescence** axillary cylindrical spike, receptacle not enlarged, sometimes clustered in terminal or axillary pseudo-racemes; involucre absent or consisting of 1 or 2 small, early deciduous bracts; floral bracts linear, early deciduous. **Flowers** sessile, creamy white, with a basal cupular nectariferous disk; calyx 5-lobed; corolla 5-lobed, the lobes one third to half the length of the corolla; stamens numerous (30)50-80(115), distinct; anther glands usually present; pollen comprising 16 grained polyads; ovary stipitate, usually glabrous. **Legumes** oblong, straight, strongly flattened, not constricted between the seeds, dehiscent along both sutures, mostly chartaceous, transversely to irregularly striate (rarely not striate), with a distinct stipe. **Seeds** uniseriate, not winged, strongly flattened, smooth, not surrounded by pulp; usually with a large U-shaped pleurogram covering 50%-70% of the seed.

Key to the species of the genus *Mariosousa*.

- a. Bark of trunk and major branches smooth, white to reddish yellow to light gray, exfoliating and papery
 - b. Pinnae 1 (rarely 2 or 3) pair/leaf; most petioles flattened, many more than 130 mm long *Mariosousa heterophylla*
 - b. Pinnae 2 to 18 pairs/leaf; petioles terete in cross section, less than 130 mm long.
 - c. Pinnae 2 to 7 pairs/leaf; 4-40 mm between pinna pairs; 1.8-3.3 mm between leaflet pairs (northern Sinaloa, Mexico) *Mariosousa gentryi*
 - c. Pinnae 7 to 18 pairs/leaf; 4-15 mm between pinna pairs; 0.8-1.6 mm between leaflet pairs *Mariosousa salazarii*
- a. Bark not as above, mostly shallowly furrowed, fissured, rough and scaly, not exfoliating and papery.
 - d. Pinnae mostly with more than 36 pairs of leaflets, especially those near the middle of the rachis.
 - e. Petiolar gland flattened, usually located on the lower third of the petiole; leaflet apex obtuse to broadly acute.
 - f. Leaflets 1.2-1.9 mm wide; most leaves with 7 to 15 pairs of pinnae. *Mariosousa usumacintensis*
 - f. Leaflets less than 1.3 mm wide; leaves with 2 to 7(8) pairs of pinnae. *Mariosousa dolichostachya*
 - e. Petiolar gland saucer-shaped to cup-shaped, usually located on the upper half of the petiole, rarely absent; leaflet apex narrowly acute to acuminate.
 - g. Minute purple glands common at the base of the leaflet, and usually along the rachis; leaflets lacking long hairs on the lower side at the base *Mariosousa acatlensis*
 - g. Minute purple glands absent; leaflets usually with long hairs on the lower side at the base. *Mariosousa centralis*
 - d. Pinnae mostly with fewer than 36 pairs of leaflets.
 - h. Leaves less than 30 mm long; some clustered on short shoots. *Mariosousa compacta*
 - h. Leaves mostly more than 30 mm long; short shoots absent.
 - i. Leaflets appressed to erect pubescent on both surfaces, usually densely so.
 - j. Petiole and rachis densely pubescent with erect hairs about 0.3 mm long; fruit pubescent. *Mariosousa sericea*
 - j. Petiole and rachis with short, appressed hairs; fruit glabrous or nearly so.
 - k. Petiolar glands raised, the apex bulbous; pinnae 1 to 6 (9) pairs/leaf. *Mariosousa mammiifera*
 - k. Petiolar glands sessile and with an irregularly raised apex; pinnae 5 to 13 pairs/leaf. *Mariosousa durangensis*
 - i. Leaflets glabrous to lightly appressed pubescent beneath.
 - l. Leaves mostly with a single pair of pinnae (rarely 2 or 3); many petioles more than 100 mm long. *Mariosousa heterophylla*
 - l. Leaves mostly with 4 or more pairs of pinnae; petioles less than 70 mm long.
 - m. Rachis gland between the upper pinna pair stalked; shrub or small tree usually less than 4 m tall. *Mariosousa millefolia*
 - m. Rachis gland between the upper pinna pair sessile; usually saucer-shaped, cup-shaped, or absent; large shrub or tree, usually more than 4 m tall.
 - n. Petiolar glands absent on many petioles; leaflet apex acuminate; bark of trunk and large branches exfoliating and papery; (many herbarium specimens of *Mariosousa salazarii* lack this information) . . . *Mariosousa salazarii*
 - n. Petiolar glands present; leaflet apex broadly acute to obtuse; bark smooth

to furrowed, not exfoliating or papery.

o. Leaflets appressed pubescent beneath; rachis and pinna rachises

pubescent; sepals and petals pubescent *Mariosousa coulteri*

o. Leaflets glabrous beneath; rachis and pinna as well as the sepals and

petals glabrous. *Mariosousa russelliana*

1. *Mariosousa acatlensis* (Benth.) Seigler & Ebinger in Seigler et al., Novon 16(3): 417. 2006a. Basionym: *Acacia acatlensis* Benth., London J. Bot. 1:513. 1842. *Senegalia acatlensis* (Benth.) Britton & Rose, N. Amer. Fl. 23(2): 112. 1928. **TYPE:** Mexico. Puebla. Acatlán, 18 May 1830, G. Andrieux 396 (lectotype, designated here, K [barcode] K000081898; isoelectotypes, A [bc] 00065286, G [bc] G00364601, K at F [27891], M, MEXU, MICH, NY, TEX, US [bc] 00000562). [= *Senegalia submontana* Britton & Rose, 1928.] (Fig. 1)

Shrub or small **tree** to 15 m tall; bark dark gray, shallowly furrowed; twigs light brown to greenish brown, not flexuous, glabrous to lightly puberulent; short shoots absent. **Leaves** alternate, 50-150 mm long; stipules narrowly linear, 0.8-3 x 0.2-0.6 mm near the base, usually glabrous, persistent; petiole adaxially shallowly grooved, 15-40 mm long, glabrous or nearly so, minute purple glands present; petiolar gland solitary, located between the lowermost pinna pair or along the upper half of the petiole, sessile, nearly circular to elongated, 0.7-2.3 mm long, saucer-shaped to cup-shaped, glabrous, rarely absent; rachis adaxially grooved, 20-110 mm long, glabrous to lightly puberulent, minute purple glands present, a sessile, cup-shaped gland, 0.4-0.9 mm across, between the upper 1 to 3 pinna pairs; pinnae 6 to 30 pairs/leaf, 25-60 mm long, 3-7 mm between pinna pairs; paraphyllidia 0.3-1.0 mm long; petiolules 0.8-2.6 mm long; leaflets 36 to 60 pairs/pinna, opposite, 0.5-1.2 mm between leaflet pairs, linear, 2.5-4.8 x 0.7-1.1 mm, glabrous and commonly light greenish purple above, lateral veins obvious, 1 to 3 veins from the base, margins ciliate, apex narrowly acute to acuminate, midvein subcentral. **Inflorescence** a loosely flowered cylindrical spike 40-100 mm long, 1 to 4 from the leaf axil, or in terminal racemose clusters; peduncle 5-10 x 0.5-1.0 mm, glabrous to lightly puberulent; floral bracts linear, to 1 mm long, glabrous, early deciduous. **Flower** calyx 1.0-1.8 mm long, lightly appressed pubescent; corolla 2.1-2.8 mm long, lightly appressed pubescent; stamen filaments 4.5-6.5 mm long; stipe of ovary to 0.4 mm long. **Legumes** 80-170 x 13-25 mm, cartilaginous, transversely striate, glabrous, eglandular; stipe to 20 mm long; apex broadly acute. **Seeds** oval, 7-10 x 4.5-7.2 mm, dark reddish brown; pleurogram U-shaped, 1.2-2.3 mm across.

Phenology: Flowering March-June.

Local Names: borreguitos, chindata, chondata, chivo, tiñu, tlahuintole, yepaquilitl (Rico Arce 2001).

Conservation Status: Least Concern.

Distribution: Dry, deciduous, tropical forests and thorn-scrub forests between 500 and 2100 m elevation in the states of Chiapas, Colima, Guerrero, Jalisco, México, Michoacán, Nayarit, Oaxaca, Puebla, Sinaloa, and Zacatecas, Mexico.

Discussion: Bentham noted only the one collection in the 1842 protologue. Among the several duplicates seen, the *Andrieux 396* specimen at Kew was chosen as the lectotype because it is in full flower and annotated by Bentham.

Mariosousa acatlensis and *M. centralis* (Britton & Rose) Seigler & Ebinger, in Seigler et al. are very similar, and it is possible they should be considered subspecies or varieties under the older name *Mariosousa acatlensis*. The two can be separated based on the presence or absence of minute purple glands that are common at the base of the leaflets, in the grooves of the rachis and petiole, and not uncommonly along the axis of the inflorescence in *M. acatlensis*. Both are widely distributed in southern Mexico, although *M. centralis* has been collected more frequently in the southernmost part of Mexico and, unlike *M. acatlensis*, occurs in Guatemala and countries to the south.

In the northern parts of its range in Guerrero, Jalisco, and Michoacán, *Mariosousa acatlensis* is sympatric with, and possibly hybridizes with, *M. salazarii* (Britton & Rose) Seigler & Ebinger, in Seigler et al. (2006a). The minute purple glands, the large number of leaflets per pinna pair (more than 36), and

the short petiolules (less than 2.5 mm long) separate *M. acatlensis* from that taxon. Occasional specimens were encountered that exhibited a mixture of characteristics of these two species. This involved a few specimens with some leaves with more than 40 pair of leaflets per pinna, typical of *A. acatlensis*, but with petiolules that exceeded 2.5 mm, and papery, exfoliating bark, characteristics of *M. salazarii*.

2. *Mariosousa centralis* (Britton & Rose) Seigler & Ebinger, in Seigler et al., Novon 16(3): 417. 2006a. Basionym: *Senegalia centralis* Britton & Rose, N. Amer. Fl. 23(2): 113. 1928. *Acacia centralis* (Britton & Rose) Lundell, Contr. Univ. Michigan Herb. 4: 7. 1940. **TYPE**: El Salvador. “[N]ear San Salvador, 1923, S. Calderón 1774 (holotype, NY [barcode] NY00003308 [fls.], NY photo at F Neg. No. 53554; isotypes, BM [bc] BM000645740 [fls.], GH [bc] GH00063728 [fls.], US-1165767 [bc] US00000681 [fls.]). (Fig. 2)

Tree to 25 m tall; bark dark grayish brown, vertically fissured, rough and scaling; twigs light brown to greenish brown, not flexuous, mostly glabrous; short shoots absent. **Leaves** alternate, 70-180 mm long; stipules narrowly linear, 1.0-4.5 x 0.2-0.6 mm wide near the base, glabrous, persistent; petiole adaxially shallowly grooved, 18-46 mm long, glabrous to lightly puberulent, minute purple glands absent; petiolar gland solitary, located on the middle part of the petiole, sessile, circular to oblong, 1.0-2.6 mm across, saucer-shaped to cup-shaped, glabrous; rachis adaxially grooved, 40-150 mm long, glabrous to puberulent, minute purple glands absent, a sessile saucer-shaped to doughnut-shaped gland, 0.6-1.3 mm across, between the upper 1 to 2 pinna pairs; pinnae (4)11 to 24 pairs/leaf, 30-70 mm long, 3-10 mm between pinna pairs; paraphyllidia 0.3-0.7 mm long; petiolules 0.6-2.5 mm long; leaflets 40 to 60 pairs/pinna, opposite, 0.5-1.2 mm between leaflet pairs, linear, 3.0-5.5 x 0.6-1.2 mm, glabrous except for occasional long hairs at the base beneath, lateral veins obvious, 1 to 3 veins from the base, margins ciliate, apex narrowly acute to acuminate, midvein subcentral. **Inflorescence** a loosely flowered cylindrical spike 60-140 mm long, 1 to 3 from the leaf axil, or in terminal racemose clusters; peduncle 4-10 x 0.5-1.0 mm, glabrous to lightly puberulent; floral bracts linear, to 1 mm long, usually glabrous, early deciduous. **Flower** calyx 0.7-1.3 mm long, lightly appressed pubescent; corolla 1.8-2.5 mm long, lightly appressed pubescent; stamen filaments 4.5-6.5 mm long; stipe of ovary to 0.3 mm long. **Legumes** 100-160 x 16-28 mm, cartilaginous, transversely striate, glabrous, eglandular; stipe 15-20 mm long; apex broadly acute to obtuse and usually apiculate. **Seeds** nearly circular, 6-9 mm across, dark reddish brown; pleurogram U-shaped, 1.5-3.0 mm across.

Phenology: Flowering April-August, and sporadically throughout the year when moisture is available.

Local Names: gache (Rico Arce 2001).

Conservation Status: Least Concern.

Distribution: Lowland forests, and moist disturbed sites below 1300 m in Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica, and the states of Chiapas, Jalisco, Oaxaca, and Sinaloa, Mexico.

Discussion: Britton and Rose (1928: 113) indicated the “Type from near El Salvador” as the collection *Calderon 1774* in the protologue for *Senegalia centralis*. The NY holotype of *Senegalia centralis* was in flower and good leaf condition and was annotated by Britton as “co-type” on the original label at sheet lower right. Such annotation of “co-type” doesn't appear on the other duplicates examined.

A tall tree, sometimes entering the canopy of moist lowland forests, *Mariosousa centralis* is also a common component of disturbed habitats at lower elevation through most of Central America. Most collections are from roadsides, disturbed pastures, and gallery forests.

See *M. acatlensis* remarks concerning the similarity of these two species.

3. *Mariosousa compacta* (Rose) Seigler & Ebinger, in Seigler et al., Novon 16(3): 417. 2006a. Basionym: *Acacia compacta* Rose, Contr. U. S. Natl. Herb. 8(1): 31. 1903. *Senegalia compacta* (Rose) Britton & Rose, N. Amer. Fl. 23(2): 111. 1928. **TYPE**: México. Oaxaca. “Tomellin Canon,” 24 Jun. 1899, J. N. Rose & W. Hough 4680 (lectotype, designated here, US [barcode] US00000570 [fls., fr.]; isolectotypes, GH [bc] GH00058224 [fls.], K [bc] K000081897 [fls.], NY [bc] NY00001460, fragm., photo ex US). [= *Lysiloma standleyanum* Britton & Rose, 1928.] (Fig. 3)

Shrub or small **tree** to 6 m tall; bark dark gray, flaking-off in thin strips; twigs light brown to dark reddish brown, slightly flexuous, pubescent to glabrous, when young with minute purple glands; short shoots commonly present at to immediately above the nodes, to 3 mm long, covered with acuminate stipules and old leaf bases. **Leaves** alternate, also clustered on the short shoots, 5-30 mm long; stipules narrowly linear, 1.5-3.0 x 0.2-0.5 mm near the base, usually glabrous, persistent; petiole adaxially grooved, 2.5-14.0 mm long, usually pubescent, minute purple glands present; petiolar gland solitary, located at or just below the lowermost pinnae pair, sessile to short-stalked, circular, 0.3-1.1 mm across, doughnut-shaped, glabrous; rachis adaxially grooved, 0-20 mm long, occasionally pubescent; minute purple glands present, a sessile, saucer-shaped gland, 0.2-0.6 mm across, occasionally present between the uppermost pinna pair; pinnae 1 to 6 pairs/leaf, 6-18 mm long, 2-5 mm between pinna pairs; paraphyllidia absent; petiolules 0.4-1.2 mm long; leaflets 8 to 24 pairs/pinna, opposite, 0.5-0.9 mm between leaflet pairs, oblong, 0.8-3.0 x 0.5-0.9 mm, glabrous above, usually lightly pubescent beneath with long hairs, lateral veins not obvious, only 1 vein from the base, margins usually ciliate, apex acute to obtuse, midvein subcentral. **Inflorescence** a loosely flowered cylindrical spike 30-70 mm long, solitary (rarely 2 to 3) from the leaf axil; peduncle 6-13 x 0.4-0.7 mm, usually pubescent; floral bracts linear, to 1.5 mm long, pubescent, early deciduous. **Flower** calyx 1.1-1.8 mm long, densely appressed pubescent; corolla 2.1-3.3 mm long, densely appressed pubescent; stamen filaments 5.5-8.0 mm long; stipe of ovary to 0.4 mm long. **Legumes** 50-120 x 10-20 mm, cartilaginous, transversely striate, glabrous, eglandular; stipe 5-8 mm long; apex acuminate and usually beaked. **Seeds** near circular, 5-8 mm across, purplish brown; pleurogram U-shaped, 1.3-2.2 mm across.

Phenology: Flowering April-July.

Local Names: None known.

Conservation Status: This species has a very restricted distribution and occurs in widely scattered and fragmented populations (vulnerable).

Distribution: Thorn-scrub forests, thickets, rocky slopes and washes between 500 and 1600 m elevation in the states of Puebla and Oaxaca, Mexico.

Discussion: Rose (1903) indicated only the single collection *Rose & Hough 4680* in the protologue for *Acacia compacta*, but no herbarium of deposit nor designation of type was indicated. The current designation of the US lectotype among the known duplicates clarifies this. The US type has representative material, including flowers and fruit. *Mariosousa compacta* is a much-branched shrub that rarely exceeds 3 m in height. All material of this species that has been examined is from xeric habitats, usually on rocky slopes and in washes, where *M. compacta* forms small thickets (Rico Arce and Rodríguez 1998).

4. *Mariosousa coulteri* (Benth. in A. Gray) Seigler & Ebinger, in Seigler et al., Novon 16(3): 417. 2006a. Basionym: *Acacia coulteri* Benth. in A. Gray, Smithsonian Contr. Knowl. 3(5): 66-67. [Pl. Wright., Pt. 1.] 1852, as "*Coulteri*." *Senegalia coulteri* (Benth. in A. Gray) Britton & Rose, N. Amer. Fl. 23(2): 112. 1928. **TYPE:** México. Hidalgo: Zimapán, *T. Coulter s.n.* (lectotype, designated here, K [barcode] K000081894, K Neg. No. 15548 [fls., sketch of fruit; Hb. Bentham., 1854 stamp], K photos at F, GH, MEXU, MICH, MO; isotype, US [bc] US00000577, K fragm., photo at US). (Fig. 4)

Shrub or small **tree** to 15 m tall; bark dark gray, shallowly furrowed; twigs light brown to greenish brown, not flexuous, glabrous to lightly appressed puberulent; short shoots absent. **Leaves** alternate, 50-150 mm long; stipules narrowly linear, 0.8-2.5 x 0.2-0.5 mm near the base, glabrous, tardily deciduous; petioles adaxially shallowly grooved, 20-55 mm long, usually lightly appressed puberulent, minute purple glands absent; petiolar gland solitary, located on the upper third of the petiole and commonly just below the lowermost pinna pair, sessile, circular to slightly oblong, 0.5-1.6 mm across, usually doughnut-shaped, glabrous, rarely absent; rachis adaxially shallowly grooved, 20-100 mm long, lightly puberulent, minute purple glands absent, a sessile, cup-shaped gland, 0.4-0.9 mm across, between the upper pinna pair and sometimes others; pinnae (3)4 to 11 pairs/leaf, 35-90 mm long, 6-12 mm between pinna pairs; paraphyllidia 0.3-0.7 mm long; petiolules 2-6 mm long; leaflets 18 to 38 pairs/pinna, opposite, 1.5-2.3 mm between leaflet pairs, oblong, 4.5-7.5 x 1.4-2.1 mm, glabrous above, lightly appressed pubescent beneath, lateral veins obvious, 1 to 3 veins from the base, margins usually ciliate, apex broadly acute to obtuse, midvein

subcentral. **Inflorescence** a loosely flowered cylindrical spike 50-100 mm long, 1 to 4 from the leaf axil, or rarely in terminal racemose clusters; peduncle 7-13 x 0.5-1.0 mm, usually puberulent; floral bracts linear, to 1 mm long, puberulent, early deciduous. **Flower** calyx 1.2-1.7 mm long, lightly appressed pubescent; corolla 1.9-2.6 mm long, lightly appressed pubescent; stamen filaments 5.0-7.2 mm long; stipe of ovary to 0.4 mm long. **Legumes** 100-185 x 16-25 mm, cartilaginous, transversely striate, glabrous, eglandular; stipe 11-15 mm long; apex acute to acuminate. **Seeds** circular to nearly oblong, 7.3-10.5 x 5.5-8.5 mm, dark reddish brown; pleurogram U-shaped, 2.2-3.5 mm across.

Phenology: Flowering April-August.

Local Names: tepeguaje, palo de acro (Rico Arce 2001).

Conservation Status: Least Concern.

Distribution: Open dry forest, dense thorn scrub thickets, and dry rocky slopes below 1800 m elevation in the foothills and mountains of northeastern Mexico in the states of Coahuila, Guanajuato, Hidalgo, Nuevo León, Querétaro, San Luis Potosí, and Tamaulipas.

Discussion: Gray (1852: 62) acknowledged that “the characters of this and several other new Mimoseae were obligingly communicated by Mr. Benth.” The description of *Acacia coulteri* and its infrageneric assignment as *Vulgaris Nudiflorae*, were enclosed by quote marks by Gray, followed by the statement “Benth. in litt.” In the protologue for *Acacia coulteri*, Benth. (in Gray, 1852: 66) noted one collection by name, “Coulter; without any number,” which is specified here as the lectotype.

As employed by Rico Arce & Rodríguez (1998), Rico Arce and Fonseca (2005 [2006a]), Rico Arce (2001, 2003, 2007a, 2007b, and Cué Bär et al. (2006), the names *Acacia coulteri* and *Acacia coulteri* var. *coulteri* corresponded to both *Mariosousa salazarii* Britton & Rose) Seigler & Ebinger and *Mariosousa coulteri* (Benth. in A. Gray) Seigler & Ebinger as these species were considered by them to be synonymous. The stipules of *Mariosousa coulteri* seedlings are somewhat spinescent but are only weakly rigid after the first leaf stage and become progressively smaller and less rigid on older plants (Vassal 1972). This species is common in northeastern Mexico with most of the collections from roadsides and rocky pastures. It is abundant in the states of Tamaulipas and San Luis Potosí but becomes less common to the south. The only other species of this genus found within the range of *M. coulteri* is *M. mammiifera*.

5. *Mariosousa dolichostachya* (S. F. Blake) Seigler & Ebinger, in Seigler et al., Novon 16(3): 419. 2006a. Basionym: *Acacia dolichostachya* S. F. Blake, Proc. Biol. Soc. Washington 34(6): 43-44. 1921. *Senegalia dolichostachya* (S. F. Blake) Britton & Rose, N. Amer. Fl. 23(2): 112. 1928. **TYPE:** México. Yucatán: “Las Bocas de Silám,” May 1916, *G. F. Gaumer & Sons* 23329 (holotype, F-446819 [barcode] V0057986F [fls.], F photo Neg. No. 53553, F photos at CICY, E, NY; isotypes, E [bc] E00346085 [fls.], G [bc] G00364604 [fls.], G fragm. ex F, GH [bc] GH00058228 [fls.], GH photo at MEXU, K [bc] K000081900 [fls.], NY [bc] NY00001469, type fragm., photo, US [bc] US00000205 [fls.], US [bc] US00930671, type fragm., photo, W [bc] W 1929-0010582). (Fig. 5)

Small **tree** to 15 m tall; bark dark brown to dark gray, scaly in rectangular plates; twigs light brown to greenish brown, not flexuous, glabrous; short shoots absent. **Leaves** alternate, 40-120 mm long; stipules narrowly triangular, 0.5-1.3 x 0.1-0.5 mm near the base, glabrous, persistent; petiole adaxially shallowly grooved, 30-80 mm long, glabrous, minute purple glands absent; petiolar gland solitary, usually located on the lower half of the petiole, sessile, circular to more commonly oblong, 1.0-3.0(4.1) mm long, flattened or with slightly raised margins, glabrous, sometimes absent and rarely two; rachis adaxially grooved, 20-65 mm long, lightly puberulent, minute purple glands absent, a sessile, saucer-shaped gland, 0.6-1.5 mm across, between the upper 1 to 2 pinna pairs; pinnae 2 to 7(8) pairs/leaf, 40-75 (90) mm long, 3-9 mm between pinna pairs; paraphyllidia 0.3-0.7 mm long, sometimes absent; petiolules 0.5-4.0 mm long; leaflets 36 to 65 pairs/pinna, opposite, 0.7-1.2 mm between leaflet pairs, oblong, 3.5-6.5 (7.5) x 0.8-1.3(1.4) mm, glabrous, lateral veins usually not obvious, 1 vein from the base, margins ciliate, apex broadly acute to obtuse, midvein subcentral. **Inflorescence** a loosely flowered cylindrical spike 20-90 mm long, 1 to 3 from

the leaf axil, or rarely in terminal racemose clusters; peduncle 3-10 x 0.5-0.9 mm, glabrous to lightly puberulent; floral bracts linear, to 1 mm long, glabrous to lightly pubescent, usually not deciduous.

Flower calyx 0.5-1.2 mm long, lightly appressed pubescent; corolla 1.2-2.2 mm long, lightly appressed pubescent; stamen filaments 3-5 mm long; stipe of ovary to 0.3 mm long. **Legumes** 70-160 x 12-20 mm, cartilaginous, transversely striate, glabrous, eglandular; stipe 8-12 mm long, apex acute to acuminate. **Seeds** nearly circular to oval, 5-7 mm across, purplish brown; pleurogram U-shaped, 1.5-2.2 mm across.

Phenology: Flowering April-July.

Local Names: None known.

Conservation Status: According to Rico Arce (2001) the natural habitat of this species has been considerably reduced and this species is listed as vulnerable.

Distribution: Common in thorn-scrub thickets, and disturbed wet forests in the lowlands of the states of Campeche, Chiapas, Quintana Roo and Yucatán, Mexico. Rico Arce (2001) lists this species for the Central American counties of Belize, Guatemala, and Nicaragua.

Discussion: Most specimens of *Mariosousa dolichostachya* which we have examined have a solitary petiolar gland located along the lower third of the petiole. However, rare individuals occasionally have two glands along the petiole. We have found one specimen from near Xpuíjl (Campeche, Mexico) where a petiolar gland was located just below the lowermost pinna pairs as well as a second near the middle of the petiole (Seigler & Maslin 16044, ILL).

6. *Mariosousa durangensis* (Britton & Rose) Seigler & Ebinger, in Seigler et al., Novon 16(3): 419. 2006a. Basionym: *Senegalia durangensis* Britton & Rose, N. Amer. Fl. 23(2): 112. 1928. *Acacia durangensis* (Britton & Rose) Jawad et al., Ann. Missouri Bot. Gard. 87(4): 541-542. 2000 [Jan. 2001]. *Acacia coulteri* Benth. var. *durangensis* (Britton & Rose) L. Rico, Amer. Sp. *Acacia*, 72-73. 2007. **TYPE:** México. Durango: San Ramón, 21 Apr.-18 May 1906, *E. J. Palmer 107* (lectotype, designated here, NY [barcode] NY00003311-02 [fls., fr.], NY photo at MEXU; isoelectotypes, CM [bc] CM1099 [fls.], CM [bc] CM1100 [fls.], F-212906 [bc] V0058766F [fls.], F Neg. No. 72673, GH [bc] GH000582229 [fls.], GH [bc] GH00058231 [fls., fr.], K [bc] K000081895 [fls.], MO-197149 [bc] MO001844489 [fls.], NY [bc] NY00003311-01 [fls.], UC [bc] UC84875, US [bc] US000000688 [fls.], US [bc] US000731290 [fls.], US [bc] US000731291 [st.]). (Fig. 6)

Shrub or small **tree** to 5 m tall; bark dark gray, shallowly fissured; twigs light brown, not flexuous, puberulent; short shoots absent. **Leaves** alternate, 65-160 mm long; stipules narrowly triangular, 1.0-2.5 x 0.3-0.9 mm near the base, puberulent, persistent; petiole adaxially grooved, 30-50 mm long, puberulent and with erect hairs to 0.2 mm long, minute purple glands absent; petiolar gland solitary, located near the middle of the petiole, sessile, an elliptical mound, 1.1-2.2 mm long, apex irregularly raised with a few indentations, glabrous; rachis adaxially grooved, 50-130 mm long, puberulent, minute purple glands absent, a sessile, flattened gland, 0.4-0.8 mm across, between the upper 1 to 2 pinna pairs; pinnae 2 to 13 pairs/leaf, 45-85 mm long, 8-14 mm between pinna pairs; paraphyllidia 0.3-0.7 mm long; petiolules 2.0-4.0 mm long; leaflets 16 to 40 pairs/pinna, opposite, 1.3-2.1 mm between leaflet pairs, oblong, 5.0-7.5 x 1.3-2.1 mm, loosely pubescent on both surfaces with appressed hairs, commonly purplish above, light green to purplish green beneath, lateral veins obvious, 1 to 3 veins from the base, margins ciliate, apex obtuse to acute; midvein submarginal. **Inflorescence** a loosely flowered cylindrical spike 60-120 mm long, solitary (rarely 2) from the leaf axil, or rarely in short racemose clusters; peduncle 5-15 x 1.0-1.8 mm, puberulent; floral bracts linear, to 1 mm long, pubescent, early deciduous. **Flower** calyx, 1.0-1.4 mm long, densely appressed pubescent; corolla 2.0-3.0 mm long, densely appressed pubescent; stamen filaments 5.5-7.5 mm long; stipe of ovary to 0.4 mm long. **Legumes** 80-120 x 16-22 mm, cartilaginous, transversely striate, glabrous to lightly puberulent, eglandular; stipe 7-10 mm long; apex acuminate and usually beaked. **Seeds** not seen.

Phenology: Flowering April-June.

Local Names: None known.

Conservation Status: We have only seen four specimens including the type and agree with Rico Arce (2001) that this taxon be placed as data deficient.

Distribution: Thorn scrub forests and dry thickets, 1500 to 2200 m elevation in the states of Chihuahua, Durango, and Jalisco, Mexico.

Discussion: Britton and Rose (1928) referred to a single collection in the protologue for *Senegalia durangensis*, with no indication as type or herbarium of deposit. The NY lectotype clarifies the type among the several known duplicates, and this was first recognized by Ebinger (January 1998 determination label). Rico Arce (2007b) used the name *Acacia coulteri* var. *durangensis* to refer to probable variants of *Acacia coulteri* sensu Jawad et al. (2000 [2001]) in El Bajío, México.

The petiolar gland is the most distinctive feature of *M. durangensis*. Other species of this genus have a flat or doughnut- or torus-shaped gland, or the gland is stalked. In *M. durangensis*, in contrast, the sessile gland appears as an elliptical mound, with a few indentations. On herbarium specimens, this gland has a purple color, and rarely a few long hairs on its surface.

7. *Mariosousa gentryi* Seigler & Ebinger, Phytologia 103(3): 69-72, fig. 1. 2021. **TYPE:** Mexico. Sinaloa. Small tree with yellow peeling bark, rocky volcanic slopes with coastal thorn forest, Cerros de Navachiste about Bahía Topolobampo, 26-30 Sep 1954, H. S. Gentry 14337 (holotype, MICH; isotypes, LL, US). (Fig. 7)

Small **tree**; bark smooth, yellow, exfoliating and papery; twigs light brown to greenish brown, becoming dark reddish purple, not flexuous, glabrous to puberulent; short shoots absent. **Leaves** alternate, 30-220 mm long; stipules narrowly linear, 2-5 x 0.2-0.4 mm near the base, glabrous, persistent; petiole shallowly grooved to nearly terete in cross section, 20-130 mm long, glabrous, minute purple glands absent; petiolar gland usually absent, sometimes located between the lowermost pinna pair, sessile, circular, 0.5-1.2 mm across, globose to doughnut-shaped, glabrous; rachis not grooved, 30-130 mm long, glabrous, minute purple glands absent, a small globose gland 0.3-0.8 mm between the uppermost, and sometimes more pinna pairs; pinnae 2 to 7 pairs/leaf, 40-80 mm long, 4-40 mm between pinna pairs; paraphyllidia 0.6 mm long, commonly absent; petiolules 3-6 mm long; leaflets 15 to 25 pairs/pinna, opposite, 1.8-3.3 mm between leaflet pairs, oblong to elliptic, 4.5-10.0 x 0.9-2.2 mm, glabrous, lateral veins not obvious, only one vein from the base, margins not ciliate, apex narrowly acute to acuminate, midvein subcentral. **Inflorescence** a loosely flowered cylindrical spike 40-80 mm long, solitary (rarely 2) from the leaf axil; peduncle 8-20 x 0.5-0.8 mm, puberulent; floral bracts linear, to 1.2 mm long, glabrous to lightly pubescent, early deciduous. **Flower** calyx 1.4-2.0 mm long, lightly appressed pubescent; corolla 2.4-3.2 mm long, lightly appressed pubescent; stamen filaments 7.0-9.0 mm long; stipe of ovary to 0.1 mm long. **Legumes** 50-140 x 13-20 mm, chartaceous, transversely to irregularly striate, glabrous, eglandular; stipe to 11 mm long; apex obtuse to acute. **Seeds** oval to near circular, 6.4-11.0 x 4.5-8.0 mm, dark purplish brown; pleurogram U-shaped, 2.5 mm across.

Phenology: Flowering July.

Local Names: None known.

Conservation Status: Considering the lack of material, and the possible hybrid origin, we consider the status of this taxon to be data deficient.

Distribution: Arid hills, rocky slopes and thorn-scrub forests at lower elevations in northern Sinaloa, Mexico, in the general area of the towns of Bahía Topolobampo and Los Mochis.

Discussion: We originally considered that *Mariosousa gentryi* was of hybrid origin with *M. heterophylla* and *M. russelliana* being the putative parents (Jawad et al. 2000: 547). However, *M. heterophylla* is restricted to northern and central Sonora, well north of the range of *M. gentryi* in northern Sinaloa, Mexico. This taxon is similar to *M. heterophylla* in being small trees with exfoliating, papery bark, having petioles that sometimes exceed 100 mm in length, leaflets fewer than 26 pairs per pinna, and some pinnae that exceed 55 mm in length. They are similar to *M. russelliana* in having stipules 2-5 mm long, petioles that are shallowly grooved, and leaves with up to seven pinna pairs. Only a few specimens of this new taxon are available for study, none of which come from the area where *M. heterophylla* and *M. russelliana* are known to be sympatric.

Being restricted to a small area of northern Sinaloa, this taxon is more than 100 km south of the presently known range of *M. heterophylla*. We have tentatively concluded that *M. gentryi* represents a distinct species with a very limited geographic distribution. More information, including fieldwork and DNA analysis, will be necessary to determine the status of this taxon (Seigler and Ebinger 2021).

8. *Mariosousa heterophylla* (Benth.) Seigler & Ebinger, Phytologia 100(4): 257. [21 Dec.] 2018. Basionym: *Prosopis heterophylla* Benth., London J. Bot. 5: 82. 1846, as “*P. ? heterophylla*.” *Senegalia heterophylla* (Benth.) Britton & Rose, N. Amer. Fl. 23(2): 114. 1928. **TYPE**: México. Sonora: “Sonora alta,” 1830, *T. Coulter s. n.* (holotype, TCD). [= *Acacia willardiana* Rose in Vasey & Rose, 1890; = *Mariosousa willardiana* (Rose) Seigler & Ebinger in Seigler et al., 2006a.] (Fig. 8)

Tree to 10 m tall; bark smooth, white to reddish yellow, exfoliating and papery; twigs light gray, becoming dark reddish purple, not flexuous, glabrous; short shoots absent. **Leaves** alternate, 30-400 mm long; stipules narrowly linear, 0.5-1.1 x 0.1-0.2 mm near the base, glabrous, tardily deciduous; petiole adaxially flattened, not grooved, 20-400 mm long, usually glabrous, minute purple glands absent; petiolar gland solitary, located between to just below the lowermost pinna pair, rarely near the lower part of the petiole, sessile, nearly circular, 0.2-1.1 mm across, doughnut-shaped, glabrous; rachis flattened, not grooved, 0-100 mm long, glabrous, minute purple glands absent, a sessile, circular gland 0.2-1.1 mm across between most pinna pairs; pinnae 1 (rarely 2 or 3) pairs/leaf, 16-80 mm long; paraphyllidia absent; petiolules 2.5-10.0 mm long; leaflets 4 to 25 pairs/pinna, opposite, 1-5 mm between leaflet pairs, oblong to elliptic, 3.0-7.5(12.0) x 1.0-2.5 mm, glabrous to rarely lightly pubescent with appressed hairs on both surfaces, lateral veins not obvious, 1 vein from the base, margins glabrous to lightly ciliate, apex narrowly acute to acuminate, midvein subcentral. **Inflorescence** a loosely flowered cylindrical spike 30-90 mm long, solitary from the leaf axil, or in short racemose clusters; peduncle 5-25 x 0.4-0.8 mm, glabrous or nearly so; floral bracts linear, to 1 mm long, glabrous to lightly pubescent, early deciduous. **Flower** calyx 1.0-2.2 mm long, glabrous; corolla 2.2-3.6 mm long, glabrous; stamen filaments 6-8 mm long; stipe of ovary to 1 mm long. **Legumes** 70-180 x 8-22 mm, chartaceous, irregularly striate, glabrous, eglandular; stipe 10-14 mm long; apex obtuse. **Seeds** nearly circular, 6-12 mm across, dark brown; pleurogram not obvious, when present, U-shaped, 1.5-2.2 mm across.

Phenology: Flowering February-June.

Local Names: palo blanco, cap (Seri), nawi'o (Yaqui), Willard's acacia (Rico Arce 2001).

Conservation Status: Though native populations appear to be restricted to the state of Sonora, Mexico, this species is very common there. Least Concern.

Distribution: Arid hills, rocky slopes and washes in desert scrub vegetation between sea level and 500 m elevation in northern and central Sonora, Mexico.

Discussion: There is a fruiting specimen at TCD (barcode, TCD0000916) from Sonora Alta, 1830, that is filed as type for *Prosopis heterophylla* and might be further investigated. The collector is not named and a collection number is given as 526. Benthham mentioned *Coulter* as the single collector in the protologue for *P. heterophylla*, without collection number. Benthham remarked “I have seen but a single specimen in the herbarium of Trinity College, Dublin.” (1846: 82). A proposal to conserve the name *Acacia willardiana* Rose against *Prosopis heterophylla* Benth. (Seigler & Ebinger, 2008) was declined (Brummitt 2011; Barrie 2011).

A common species at lower elevations in the state of Sonora, *Mariosousa heterophylla* is a very conspicuous component of the desert scrub of this region because of its nearly white, to yellowish, to almost reddish, papery, exfoliating bark. Benthham (1846) tentatively assigned this taxon to *Prosopis heterophylla* based on a single fruiting specimen. He suggested that the general habit of the plant was more like that of *Prosopis* than any other genus and mentioned the almost phyllodinous vertical expansion of the petiole. Based on flowering material, Vasey and Rose (1890) realized that this taxon was an *Acacia* and used the name *Acacia willardiana*. A proposal to conserve the name *A. willardiana* Rose against *Prosopis heterophylla* Benth. (Seigler & Ebinger, 2008) was declined (Brummitt 2011; Barrie 2011). *Mariosousa*

heterophylla commonly has 90 to 115+ separate stamens per flower, nearly twice the number found in the other taxa of the genus *Mariosousa*.

9. *Mariosousa mammiifera* (Schltdl.) Seigler & Ebinger, in Seigler et al., Novon 16(3): 419. 2006a. Basionym: *Acacia mammiifera* Schltdl., Linnaea 12(5): 563-564. 1838. *Senegalia mammiifera* (Schltdl.) Britton & Rose, N. Amer. Fl. 23(2): 112. 1928. **TYPE:** México. Hidalgo: “Barranca de Acholoya,” Nov. 1845, *C. A. Ehrenberg* 845 (lectotype, designated here, HAL [barcode] HAL0071840 [frs.]; isoelectotypes, G [bc] G00364607, NY [bc] NY00001481, UC [bc] UC158125, UC [bc] UC453776, UC [bc] UC453796), US [bc] US00000245). (Fig. 9)

Shrub or small **tree** to 5 m tall; bark dark gray, shallowly fissured; twigs light brown to purplish-brown, not flexuous, usually puberulent; short shoots absent. **Leaves** alternate, 30-130 mm long; stipules narrowly triangular, 1.2-2.5 x 0.2-0.7 mm near the base, glabrous to puberulent, persistent; petiole adaxially grooved, 8-50(70) mm long, glabrous to lightly puberulent, minute purple glands usually present; petiolar gland solitary, located between the lowermost pinna pair or rarely along the upper half of the petiole, sessile to short-stalked, circular, 0.4-0.8 mm across, apex globose, glabrous; rachis adaxially grooved, 10-70 mm long, puberulent, minute purple glands usually present, a stalked gland with a globose apex, 0.4-0.6 mm across, between most pinna pairs; pinnae 1 to 6(9) pairs/leaf, 30-85 mm long, 6-15(25) mm between pinna pairs; paraphyllidia 0.3-0.7 mm long, sometimes absent; petiolules 2.0-3.8(4.5) mm long; leaflets 9 to 26(33) pairs/pinna, opposite, 1-5 mm between leaflet pairs, oblong, 4-12 x 1.5-3.5 (4.5) mm, lightly pubescent on both surfaces with appressed hairs, commonly purplish above, light green to purplish green beneath, lateral veins mostly obvious, 1 to 4 veins from the base, margins ciliate, apex obtuse to broadly acute, midvein submarginal. **Inflorescence** a loosely flowered cylindrical spike 30-90 mm long, solitary (rarely 2) from the leaf axil; peduncle 6-15(40) x 0.7-1.1 mm, puberulent; floral bracts linear, to 1.4 mm long, pubescent, early deciduous. **Flower** calyx 1.3-2.0 mm long, lightly appressed pubescent; corolla 2.2-3.5 mm long, lightly appressed pubescent; stamen filaments 6.5-8.5 mm long; stipe of ovary to 0.3 mm long. **Legumes** 80-240 x 18-34 mm, cartilaginous, transversely striate, glabrous, eglandular; stipe 8-12 mm long; apex acuminate and usually beaked. **Seeds** nearly circular, 8.0-10.5 mm across, dark brown; pleurogram U-shaped, 3-4 mm across.

Phenology: Flowering April-June.

Local Names: None known.

Conservation Status: Least concern.

Distribution: Thorn scrub forests and from the pinyon-juniper zone in dry thickets, and rocky slopes from 1300 to 2700 m elevation in the state of Guanajuato, Hidalgo, Nuevo León, Oaxaca, Puebla, Querétaro, San Luis Potosí, and Tamaulipas, Mexico.

Discussion: Schlechtendal (1838: 563) noted “Barranca de Acholoya Nov. fructis,” for an Ehrenberg collection in the protologue for *Acacia mammiifera*. The original label at sheet lower left of *Ehrenberg* 845 (HAL) corresponds to the type locality and month and the novel species name is inferred to have been written in Schlechtendal's hand. Among the several duplicates known, a fruiting specimen in good condition at HAL was chosen as lectotype. A second collection *Ehrenberg* 847 may also represent type material.

Mariosousa mammiifera is widely distributed throughout the central part of Mexico from the state of Oaxaca, north to Tamaulipas and Nuevo León. It does not appear to be a common species, many of the collections being from near the same localities in the various states. All collections examined are from above 1300 m. This may have been due to local distributions or to collectors' bias.

10. *Mariosousa millefolia* (S. Watson) Seigler & Ebinger, in Seigler et al., Novon 16(3): 419. 2006a. Basionym: *Acacia millefolia* S. Watson, Proc. Amer. Acad. Arts 21, new ser., 13: 427. 1886. *Senegalia millefolia* (S. Watson) Britton & Rose, N. Amer. Fl. 23(2): 111. 1928. **TYPE:** México. Chihuahua: “Hacienda San José, near Batopilas,” Aug. 1885, *E. J. Palmer* 45 (lectotype, designated by Isely [1969: 379], GH [barcode] GH00058244; isoelectotypes, K [bc] K000081901, MEXU, NY [bc] NY00001484, NY

[bc] NY00001483, US [bc] US00000253, US [bc] US00000254, US [bc] US00997056, US [bc] US01108116, US [bc] US01108117). (Fig. 10)

Shrub or small **tree** to 3 m tall; bark gray, smooth when young, becoming fissured into square plates 1-2 cm across; twigs light brown to greenish brown, not flexuous, usually lightly puberulent; short shoots absent. **Leaves** alternate, 60-230 mm long; stipules narrowly linear, 1.5-6.5 x 0.2-0.6 mm near the base, usually glabrous, persistent; petiole adaxially grooved, 15-75 mm long, usually glabrous, minute purple glands absent; petiolar gland mostly absent (when found the gland is between or near the lowermost pinna pair and similar to the gland terminating the rachis); rachis adaxially grooved, 50-190 mm long, glabrous to lightly pubescent, minute purple glands absent, a stalked gland with a globose apex, 0.3-0.9 mm across, between the upper 1 to 4 pinna pairs; pinnae (2)6 to 14 pairs/leaf, 20-55 mm long, (4)10-28 mm between pinna pairs; paraphyllidia 0.3-0.7 mm long; petiolules 2.0-5.5 mm long; leaflets 20 to 35(37) pairs/pinna, opposite, 0.8-1.6 mm between leaflet pairs, oblong, 2.0-6.5 x 0.7-1.4 mm, glabrous above, lightly pubescent beneath with appressed hairs, lateral veins not obvious, 1 vein from the base, margins sometimes ciliate, apex acuminate, midvein subcentral. **Inflorescence** a loosely flowered cylindrical spike 30-75 mm long, solitary (rarely 2 to 3), from the leaf axil; peduncle 5-15 x 0.3-0.8 mm, glabrous to lightly puberulent; receptacle not enlarged; floral bracts linear, to 1.3 mm long, glabrous to lightly pubescent, early deciduous. **Flower** calyx 1.1-1.6 mm long, glabrous; corolla 2.0-2.7 mm long, glabrous; stamen filaments 4.5-6.5 mm long; stipe of ovary to 0.4 mm long. **Legumes** 55-170 x 12-23 mm, chartaceous, irregularly striate, glabrous, eglandular; stipe 8-12 mm, apex acute to obtuse. **Seeds** nearly circular, 6.2-9.5 mm across, dark brown; pleurogram U-shaped, 2-3 mm across.

Phenology: Flowering June-August.

Local Names: fernleaf acacia, milfoil, Santa Rita acacia, tepemesquite blanco.

Conservation Status: Least Concern.

Distribution: Desert grasslands, rocky slopes, subtropical scrub, and open oak woodlands from 700 to 1700 m elevation in southern Arizona, extreme southwestern New Mexico, and south into the states of Chihuahua and Sonora, Mexico.

Discussion: For the name *Acacia millefolia*, a syntype was seen as *C. G. Pringle 125* at GH (barcode, GH00283182) as well as other Pringle collections that are not typic, seen at A (barcode, A00283183), F (barcode, V0092364F), JE (barcode, JE00019747), NY (barcodes, NY00001442, NY00001443), and PH (50139, 50140, 50141, 50143).

Though numerous specimens are available from throughout most of the geographic range of this taxon, no specimen, other than the type collection, is known from Chihuahua. This taxon may be extremely rare in southwestern Chihuahua, or it is possible that the collecting data on the type specimens is incorrect. This collection, *Palmer 45*, which was designated as the lectotype by Isley (1969), is more than 100 km east of any specimens of *M. millefolia* seen by the present authors, and the only specimen we have seen from the state of Chihuahua. Also, *M. millefolia* is extremely rare in New Mexico. We have seen only one collection from the extreme southwestern corner of Hidalgo County, New Mexico, about 1 km from the Arizona/New Mexico border (*R. Spellenberg & R. Repass 5371*, NMC).

11. *Mariosousa russelliana* (Britton & Rose) Seigler & Ebinger, in Seigler et al., Novon 16(3): 419. 2006a. Basionym: *Senegalia russelliana* Britton & Rose, N. Amer. Fl. 23(2): 112. 1928, as "*Russelliana*." *Acacia russelliana* (Britton & Rose) Lundell, Contr. Univ. Michigan Herb. 4: 7. 1940. **TYPE:** México. Sinaloa: "vicinity of San Blas," 22 Mar. 1910, *J. N. Rose, P. C. Standley & P. G. Russell 13204* (lectotype, designated here, US-636032 [barcode] US00000711 [fls.]; isolectotypes, GH [bc] GH00057355 [fls.], NY [bc] NY00003325 [fls.]). (Fig. 11)

Shrub or small **tree** to 8 m tall; bark dark-gray, shallowly furrowed; twigs light brown to greenish brown, not flexuous, glabrous; short shoots absent. **Leaves** alternate, 60-140 mm long; stipules narrowly linear, 0.6-2.5 x 0.2-0.6 mm near the base, glabrous, tardily deciduous; petiole adaxially shallowly grooved, 20-50 mm long, glabrous, minute purple glands absent; petiolar gland solitary, located near the middle of the

petiole to just below the lowermost pinna pair, sessile, usually circular, 0.4-1.5 mm across, doughnut-shaped to urn-shaped, glabrous, rarely absent; rachis adaxially shallowly grooved, 30-90 mm long, glabrous, minute purple glands absent, rarely a sessile, doughnut-shaped gland, 0.4-0.9 mm across, between the uppermost pinna pair; pinnae (2)4 to 11 pairs/leaf, 25-70 mm long, 4-12 mm between pinna pairs; paraphyllidia absent; petiolules 2.0-3.5 mm long; leaflets 18 to 40 pairs/pinna, opposite, 0.9-1.8 mm between leaflet pairs, oblong, 3.5-7.5 x 1.2-1.8 mm, glabrous, lateral veins obvious, 1 to 4 veins from the base, margins sometimes lightly ciliate, apex obtuse to broadly acute, midvein subcentral. **Inflorescence** a loosely flowered cylindrical spike 25-60 mm long, solitary (rarely 2 to 3) from the leaf axil, or rarely in terminal racemose clusters; peduncle 1-10 x 0.4-0.7 mm, glabrous; floral bracts linear, to 1 mm long, glabrous, early deciduous. **Flower** calyx 0.9-1.4 mm long, glabrous; corolla 1.7-2.5 mm long, glabrous; stamen filaments 4.5-6.5 mm long; stipe of ovary to 0.4 mm long. **Legumes** 55-170 x 16-27 mm, cartilaginous, transversely striate, glabrous, eglandular; stipe 5-15 mm long, apex acute to obtuse, sometimes beaked. **Seeds** circular to oval, 6.8-9.6 x 5.1-8.0 mm, reddish-brown; pleurogram U-shaped, 2-3 mm across.

Phenology: Flowering March-August.

Local Names: None known.

Conservation Status: Least Concern.

Distribution: Dry, deciduous, tropical forests to thorn-scrub and desert-scrub vegetation, mostly on rocky slopes, from near sea level to about 1000 m elevation in the states of Sinaloa, and Sonora, Mexico.

Discussion: In the protologue for *Senegalia russelliana*, Britton and Rose (1928) mentioned the collection (Rose *et al.* 13204) as type but did not provide further detail for any herbaria of deposit. The US specimen chosen here for the lectotype is in good flowering condition, with more vegetative material than the other two duplicates. The US sheet was earlier annotated as lectotype by Ebinger (January 1998 determination), but the action was not published.

A small shrub or understory tree, *Mariosousa russelliana* is encountered in southern Sonora and northern Sinaloa where it appears to be common. It is also found as an understory tree in tropical deciduous forests. We originally thought that *M. russelliana* may occasionally hybridize with *M. willardiana* in southern Sonora and northern Sinaloa, Mexico, but more detailed studies indicate that this is unlikely.

12. *Mariosousa salazarii* (Britton & Rose) Seigler & Ebinger, in Seigler *et al.*, Novon 16(3): 419. 2006a. Basionym: *Senegalia salazarii* Britton & Rose, N. Amer. Fl. 23(2): 113. 1928, as “*Salazari*.” *Acacia salazarii* (Britton & Rose) Lundell, Contr. Univ. Michigan Herb. 4: 8. 1940. **TYPE:** México. Michoacán: Xochiapa, 13 Apr. 1912, *F. Salazar s. n.* (lectotype, designated here, US-1169811 [bc] US00000712 [fls.]; isoelectotypes, MEXU [bc] MEXU00030013 [fls.], NY [barcode] NY00003326 [fls.], fragm. ex US). (Fig. 12)

Tree to 15 m tall; bark smooth, yellow to red or light gray, exfoliating and papery; twigs greenish brown to light reddish brown, not flexuous, usually glabrous; short shoots absent. **Leaves** alternate, 50-180 mm long; stipules narrowly linear, 0.9-5.5 x 0.2-0.6 mm near the base, glabrous, persistent; petiole adaxially grooved, 20-50(60) mm long, mostly glabrous, minute purple glands absent; petiolar gland solitary, located between the lowermost pinna pair, sessile, nearly circular, 0.5-1.3 mm across, globose to doughnut-shaped, commonly absent; rachis adaxially grooved, 35-140 mm long, glabrous to lightly puberulent, minute purple glands absent, a sessile, doughnut- to saucer-shaped gland, 0.5-1.0 mm across, between the upper 1 to 2(3) pinna pairs; pinnae (3)7 to 20 pairs/leaf, 35-63 mm long, 4-15 mm between pinna pairs; paraphyllidia 0.3-0.8 mm long; petiolules 2.4-4.0 mm long; leaflets 20 to 38 pairs/pinna, opposite, 0.8-1.6 mm between leaflet pairs, oblong, 2.5-6.4 x 0.9-1.7 mm, usually lightly pubescent with appressed hairs beneath, commonly light greenish-purple and glabrous above, lateral veins usually not obvious, 1(2) veins from the base, margins usually ciliate, apex narrowly acute to acuminate, midvein subcentral. **Inflorescence** a loosely flowered, cylindrical spike 45-110 mm long, 1 to 3 from the leaf axil, or rarely in terminal racemose clusters; peduncle 5-10 x 0.5-1.0 mm, lightly puberulent; floral bracts linear, to 1 mm long, puberulent,

early deciduous. **Flower** calyx 1.5-2.3 mm long, lightly appressed pubescent; corolla 2.5-3.5 mm long, lightly appressed pubescent; stamen filaments 4.5-7.5 mm long; stipe of ovary to 0.3 mm long. **Legumes** 115-180 x 20-35 mm, chartaceous, transversely striate, glabrous, eglandular; stipe 9-15 mm long; apex obtuse. **Seeds** circular to oblong, 10.0-14.5 x 7-12 mm, dark reddish brown; pleurogram U-shaped, 1.2-3.0 mm across.

Phenology: Flowering April-June.

Local Names: None known.

Conservation Status: Least Concern.

Distribution: Thorn-scrub thickets, and disturbed dry forests from near sea level to 1800 m (but mostly above 1000 m) elevation in the states of Guerrero, México, Michoacán, Morelos, Oaxaca and Puebla, Mexico.

Discussion: The US lectotype chosen here for *Senegalia salazarii* has reasonable leaf material and is in flower. The protologue (Britton & Rose, 1928: 113) identified a “F. Salazar” collection” as “type” and this typification clarifies the herbarium of deposit. The US specimen was earlier annotated by J. E. Ebinger (January 1998 determination) as a lectotype, but the action was not published. Rico Arce (2003, 2007a, 2007b) treated materials that we have cited under *Mariosousa salazarii* as *Acacia coulteri*.

Mariosousa salazarii (Britton & Rose) Seigler & Ebinger, in Seigler et al. is similar to other species of this group from southern Mexico, particularly *M. centralis* and *M. usumacintensis*, but the papery, exfoliating bark allows for easy separation. Occasionally, petiolar glands are found on a few leaf petioles of some specimens of this species, but occasional specimens lack petiolar glands altogether. These glands are usually located between the lowermost pinna pair, are sessile, nearly circular, 0.5-1.3 mm across, and globose to doughnut-shaped.

13. *Mariosousa sericea* (M. Martens & Galeotti) Seigler & Ebinger, in Seigler et al., Novon 16(3): 419. 2006a. Basionym: *Acacia sericea* M. Martens & Galeotti, Bull. Acad. Roy. Sci. Bruxelles, ser. 2, 10(2): 311. 1843. *Senegalia sericea* (M. Martens & Galeotti) Britton & Rose, N. Amer. Fl. 23(2): 111. 1928. **TYPE:** México. Puebla: Tehuacán, “les montagnes calcaires à l’est de Tehuacán,” 6,000 ft, May 1840, *H. Galeotti* 3345 (lectotype, designated here, BR [barcode] BR0000005187720 [fls.]; isoelectotypes, BR [bc] BR0000005187065, G [bc] G00364595, K [bc] K000081899, MICH, P, US [bc] US00000607, W [bc] W0004887, W-Rchb [bc] W-Rchb. 1889-0114051). [= *Acacia pueblensis* Brandegee, 1910.] (Fig. 13)

Shrub or small **tree** 3 to 4 (6) m tall; bark dark gray, cracked and fissured, breaking away and leaving dark purplish brown, smooth areas; twigs dark brown to purplish-brown, not flexuous, glabrous to lightly pubescent; short shoots absent. **Leaves** alternate, 30-120 mm long; stipules narrowly linear, 3-8 x 0.2-0.6 mm near the base, glabrous to pubescent, usually persistent; petiole adaxially grooved, 10-30 mm long, densely pubescent with erect hairs to 0.3 mm long, minute purple glands present; petiolar gland solitary, located along the petiole, sessile, circular to elliptic, 0.6-1.2 mm long, saucer-shaped to cup-shaped, glabrous, sometimes absent; rachis adaxially grooved, 15-100 mm long, pubescent with erect hairs, minute purple glands present, a sessile, saucer-shaped gland, 0.5-1.1 mm across, between the upper 1 to 2 pinna pairs; pinnae 5 to 17 pairs/leaf, 25-49 mm long, 4-8 mm between pinna pairs; paraphyllidia absent; petiolules 1.0-2.4 mm long; leaflets 14 to 35 pairs/pinna, opposite, 0.6-1.5 mm between leaflets, oblong, 2.5-5.0 x 0.8-1.5 mm, lightly pubescent on both surfaces with appressed to erect hairs, lateral veins obvious, 1(3) vein from the base, margins ciliate, apex acute to obtuse, midvein subcentral. **Inflorescence** a densely flowered cylindrical spike 30-80 mm long, solitary from the leaf axil; peduncle 3-20 x 0.7-1.2 mm, densely pubescent with erect hairs; floral bracts linear, to 3.5 mm long, densely pubescent, deciduous. **Flower** calyx 1.5-2.2 mm long, densely pubescent with erect hairs; corolla 2.0-3.3 mm long, densely pubescent with erect hairs; stamen filaments 6-8 mm long; stipe of ovary to 0.3 mm long. **Legumes** 90-170 x 15-24 mm, cartilaginous, transversely striate, pubescent, usually with minute purple glands; stipe 7-14 mm long; apex acuminate and apiculate to 5 mm long. **Seeds** circular to oblong, 6.0-10.5 mm across, dark purplish brown; pleurogram U-shaped, 1.0-2.5 mm across.

Phenology: Flowering February-June.

Local Names: None known.

Conservation Status: Least concern.

Distribution: Rocky desert and dry thorn scrub forests from 1100 to 2000 m elevation in Puebla and Oaxaca, Mexico.

Discussion: Martens and Galeotti (1843) mentioned only the one collection (*Galeotti 3345*) in protologue for *Acacia sericea*. The current typification specifies one of the two BR specimens as lectotype among the known duplicates, which is a good-quality, flowering specimen. Also described from Puebla, México, the name *Acacia pueblensis* Brandegee was later synonymized by Britton and Rose (1928: 111).

Mariosousa sericea is distinct from most other members of the genus; the dense, erect pubescence on most parts of the plant makes it easy to distinguish this taxon. *Mariosousa sericea* is known from southeastern Puebla and adjacent Oaxaca where it occurs at higher elevation, usually above 1100 m elevation, in desert and thorn scrub forests. Most collections are from roadsides, usually in dry, disturbed habitats, and many are from the Tehuacán valley (Rico Arce and Rodríguez 1998).

Mariosousa sericea possibly hybridizes with *M. acatlensis* in areas where they are sympatric. Occasional specimens were encountered with reduced pubescence and many leaflet pairs per pinna, characteristics of *M. acatlensis*. More material is necessary before an accurate determination can be made.

14. *Mariosousa usumacintensis* (Lundell) Seigler & Ebinger, in Seigler et al., Novon 16(3): 419. 2006a. Basionym: *Acacia usumacintensis* Lundell, Contr. Univ. Michigan Herb. 4: 8. 1940. **TYPE:** México. Tabasco: “Boca Cerro on the Río Usumacinta above Tenosique,” 1-5 Jul. 1939, *E. Matuda 3550* (lectotype, designated here, MICH [barcode] MICH1107068 [frs.]; isoelectotypes, A [bc] A00058277, BM, F [bc] V0058005F, GH, K [bc] K000081896, LL [bc] LL00208534, M, MEXU [bc] MEXU00081078, MICH, NY [bc] NY00001504, P, US [bc] US00000631). (Fig. 14)

Tree to 30 m tall; bark dark gray, shallowly furrowed; twigs brown to greenish brown, not flexuous, glabrous to lightly puberulent; short shoots absent. **Leaves** alternate, 90-200 mm long; stipules narrow triangular, 1-4 x 0.4-0.7 mm near the base, glabrous to lightly puberulent, persistent; petiole adaxially shallowly grooved, 25-70 mm long, glabrous to lightly puberulent, minute purple glands absent; petiolar gland solitary, usually located on the lower third of the petiole, sessile, commonly elliptic, 1-6 mm long, flattened, glabrous; rachis adaxially grooved, 50-140 mm long, glabrous to lightly puberulent, minute purple glands absent, a sessile, saucer-shaped gland, 1.0-1.9 mm across, between the upper pinna pair; pinnae 7 to 15 pairs/leaf, 55-90 mm long, 5-15 mm between pinna pairs; paraphyllidia 0.1-0.7 mm long; petiolules 1.7-3.5 mm long; leaflets (33)36 to 55 pairs/pinna, opposite, 0.9-1.6 mm between leaflets, oblong, 4-7 x 1.2-1.9 mm, glabrous, lateral veins obvious, 1 to 4 veins from the base, margins ciliate, apex broadly acute to obtuse, midvein subcentral. **Inflorescence** a loosely flowered cylindrical spike 50-110 mm long, 1 to 3 from the leaf axil, or sometimes in terminal racemose clusters; peduncle 7-15 x 0.7-1.1 mm, puberulent; floral bracts linear, to 1 mm long, puberulent, early deciduous. **Flower** calyx 1.1-1.5 mm long, densely appressed pubescent; corolla 1.8-2.6 mm long, densely appressed pubescent; stamen filaments 4-6.5 mm long; stipe of ovary to 0.3 mm long. **Legumes** 90-250 x 20-33 mm, cartilaginous, transversely striate, glabrous, eglandular; stipe 17-22 mm long; apex acute. **Seeds** oblong to oval, 8.8-10.0 x 7.0-9.0 mm, dark reddish brown; pleurogram U-shaped, 3-5 mm across.

Phenology: Flowering April-June.

Local Names: None known.

Conservation Status: Least Concern.

Distribution: Moist tropical forests, along streams, and moist disturbed sites below 500 m elevation in Belize, Guatemala, and the states of Campeche, Chiapas, Oaxaca, Tabasco and Veracruz, Mexico.

Discussion: Lundell (1940:8) noted only the one collection for *Acacia usumacintensis*, with the “Type in the University of Michigan Herbarium.” Among those duplicates known for the collection *Matuda 3550*, the lectotype is chosen between the two duplicates deposited at MICH.

We have observed no specimens of this taxon from south of Guatemala and Belize in Central America.

Specimens labeled *M. usumacintensis* from Nicaragua are the result of confusing this taxon with various species of *Lysiloma*, particularly *L. acapulcensis* (Kunth) Benth. Thompson (1980), in his revision of *Lysiloma*, annotated the type of *M. usumacintensis* as *L. acapulcensis*. This specimen (*E. Matuda 3550*), however, is *M. usumacintensis*, having numerous separate filaments remaining at the base of the fruit stipes of some fruits.

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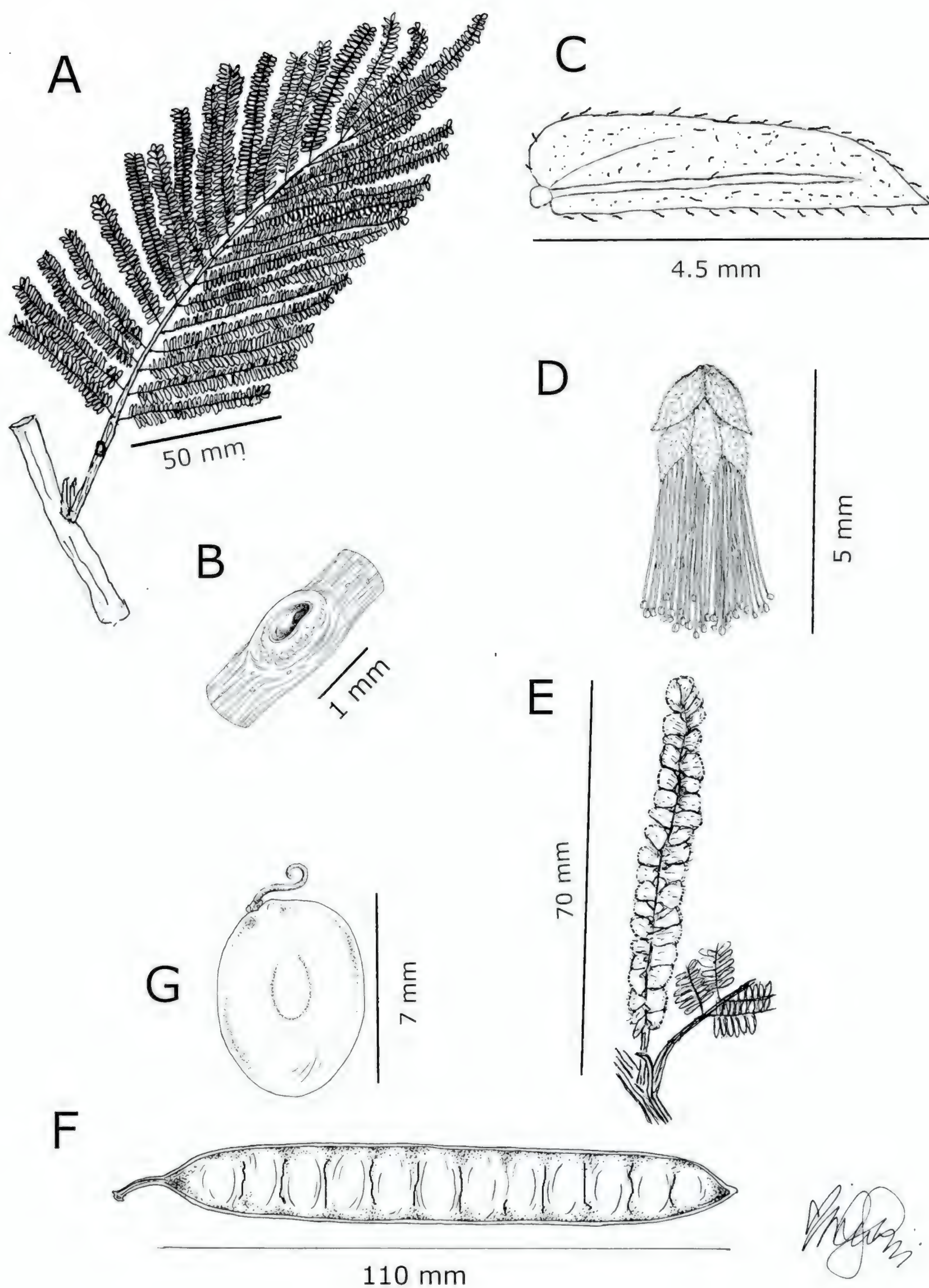


Figure 1. *Mariosousa acatlensis* (Bentham) Seigler & Ebinger in Seigler et al.; A. Leaf; B. Petiolar gland; C. Leaflet; D. Flower; E. Inflorescence; F. Fruit; G. Seed. A, C, F, G from R. S. Felger 85-38 (MO); B from M. L. Torres C. et al. 400 (MO); D, E from R. McVaugh 23271 (MICH); A-G illustrated by V. Severini.

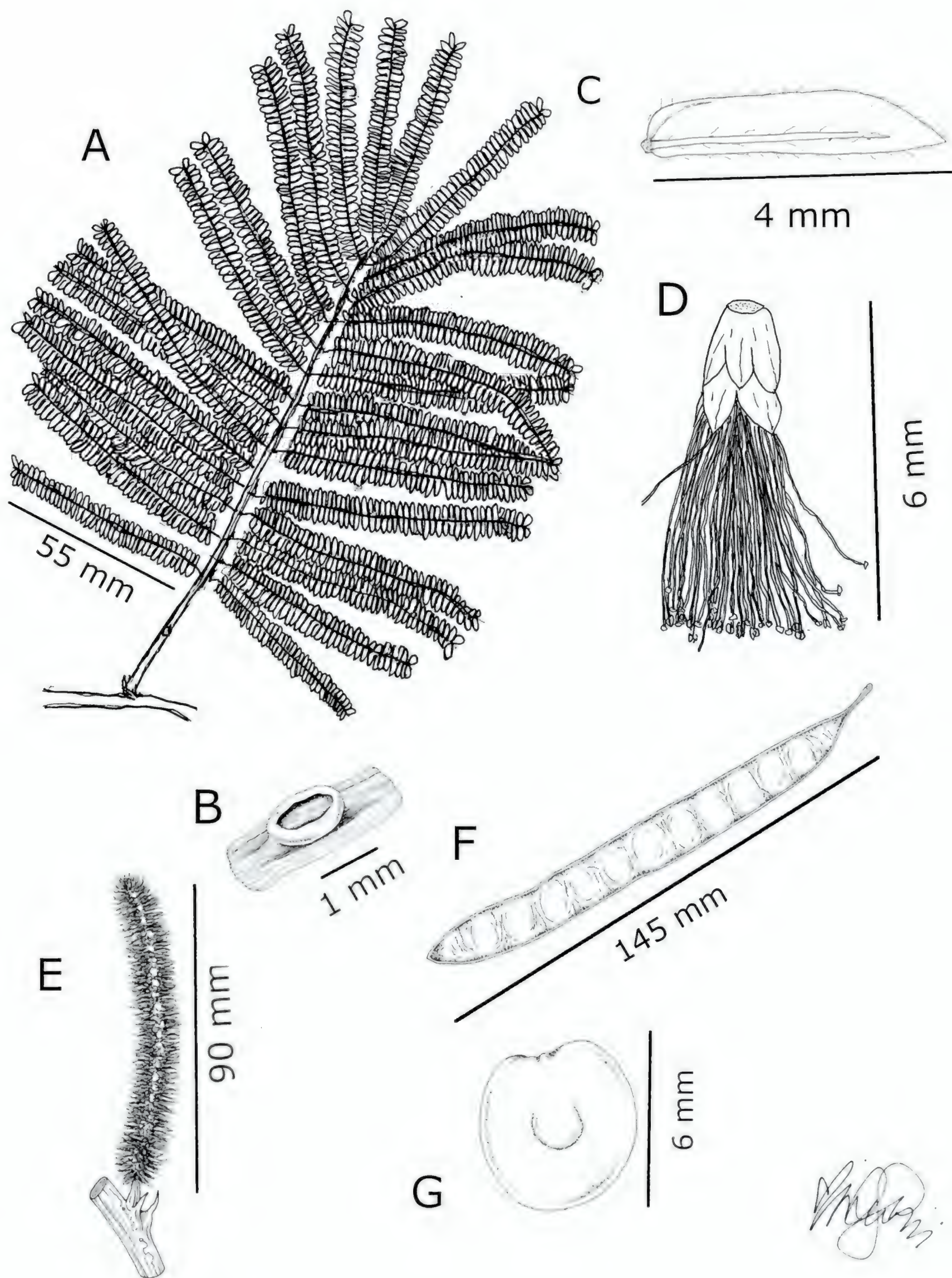


Figure 2. *Mariosousa centralis* (Britton & Rose) Seigler & Ebinger in Seigler et al.; A. Leaf; B. Petiolar gland; C. Leaflet; D. Flower; E. Inflorescence; F. Fruit; G. Seed. A, C from the A. S. Magallanes et al. 218 (MEXU); B, D, E from P. C. Vincelli 779 (MO); F, G from D. H. Janzen 10357 (MO); A-G illustrated by V. Severini.

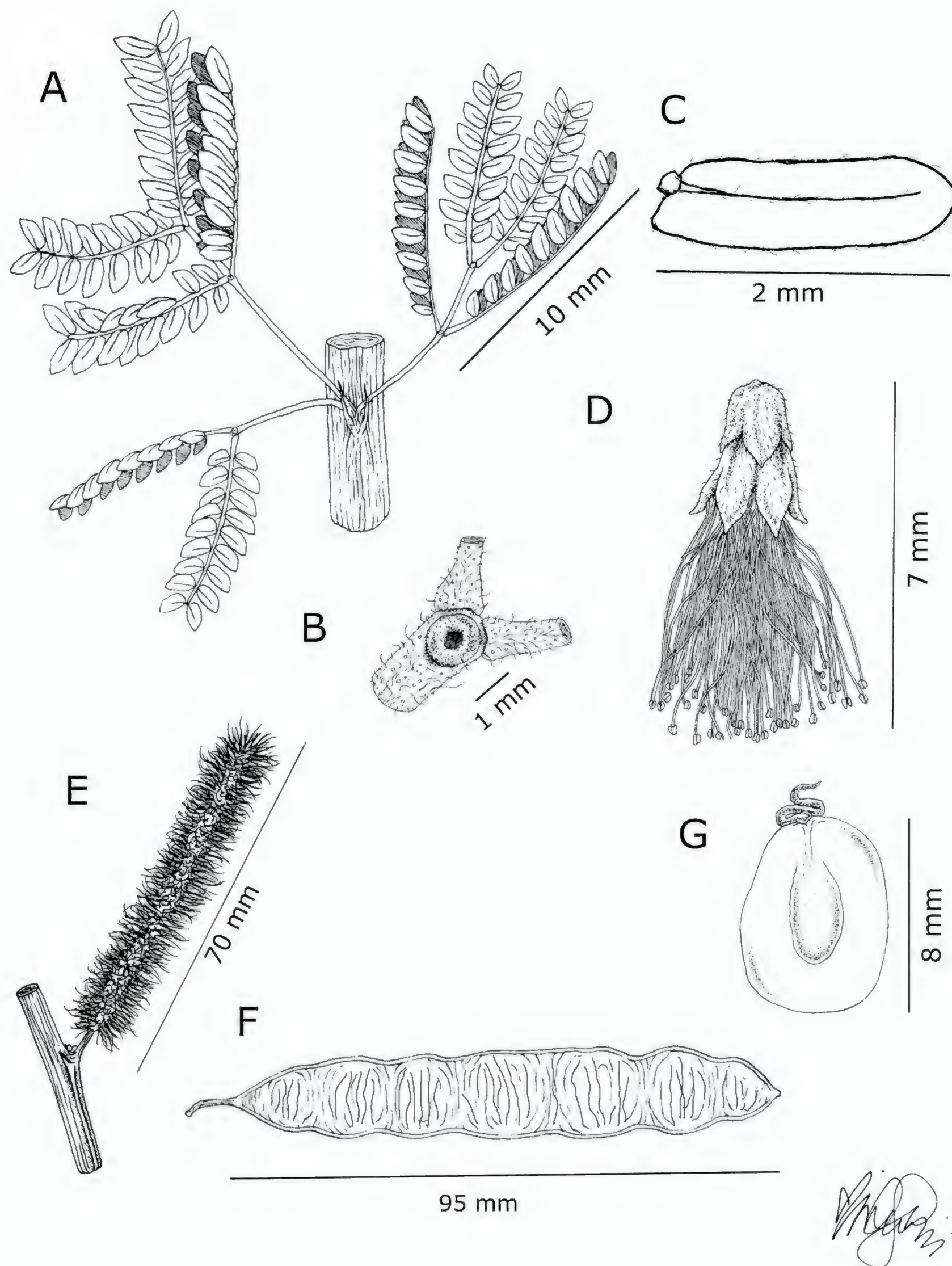


Figure 3. *Mariosousa compacta* (Rose) Seigler & Ebinger in Seigler et al.; A. Leaves; B. Petiolar gland; C. Leaflet; D. Flower; E. Inflorescence; F. Fruit; G. Seed. A, B, D, E from F. Chiang C. et al. F-2466 (RSA); C from M. Sousa & M. Sousa P. 10405 (ARIZ); F, G from M. Sousa et al. 5394 (WIS); A-G illustrated by V. Severini.

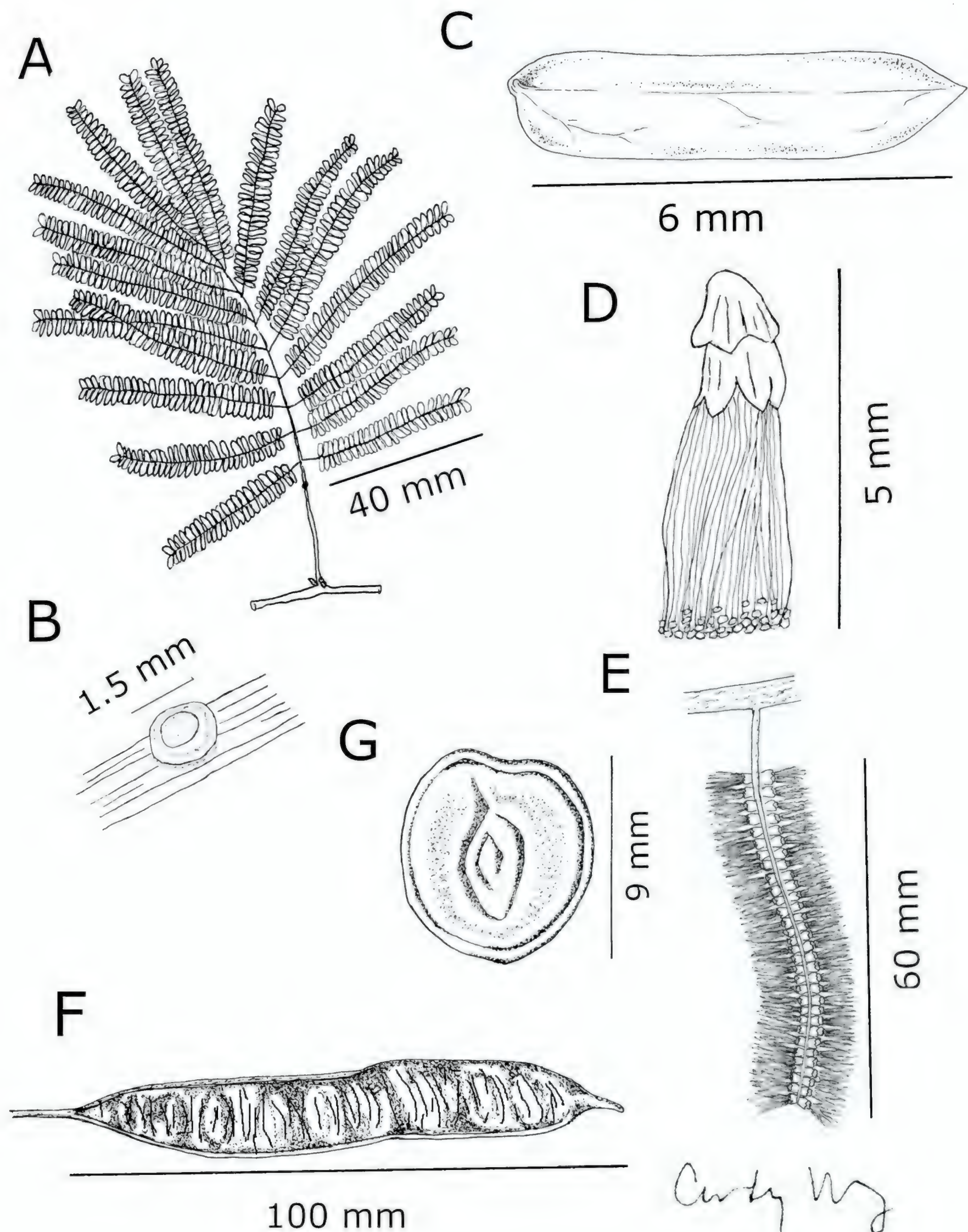


Figure 4. *Mariosousa coulteri* (Bentham) Seigler & Ebinger in Seigler et al.; A. Leaf; B. Petiolar gland; C. Leaflet; D. Flower; E. Inflorescence; F. Fruit; G. Seed. A from C. Glass & G. Glass 370 (ILL), B, F from J. Graham & M. C. Johnston 4096 (TEX); C, G from G. B. Hinton 24102 (NY); D, E from L. González Q. 2358 (MICH); A-G illustrated by C. Wang.

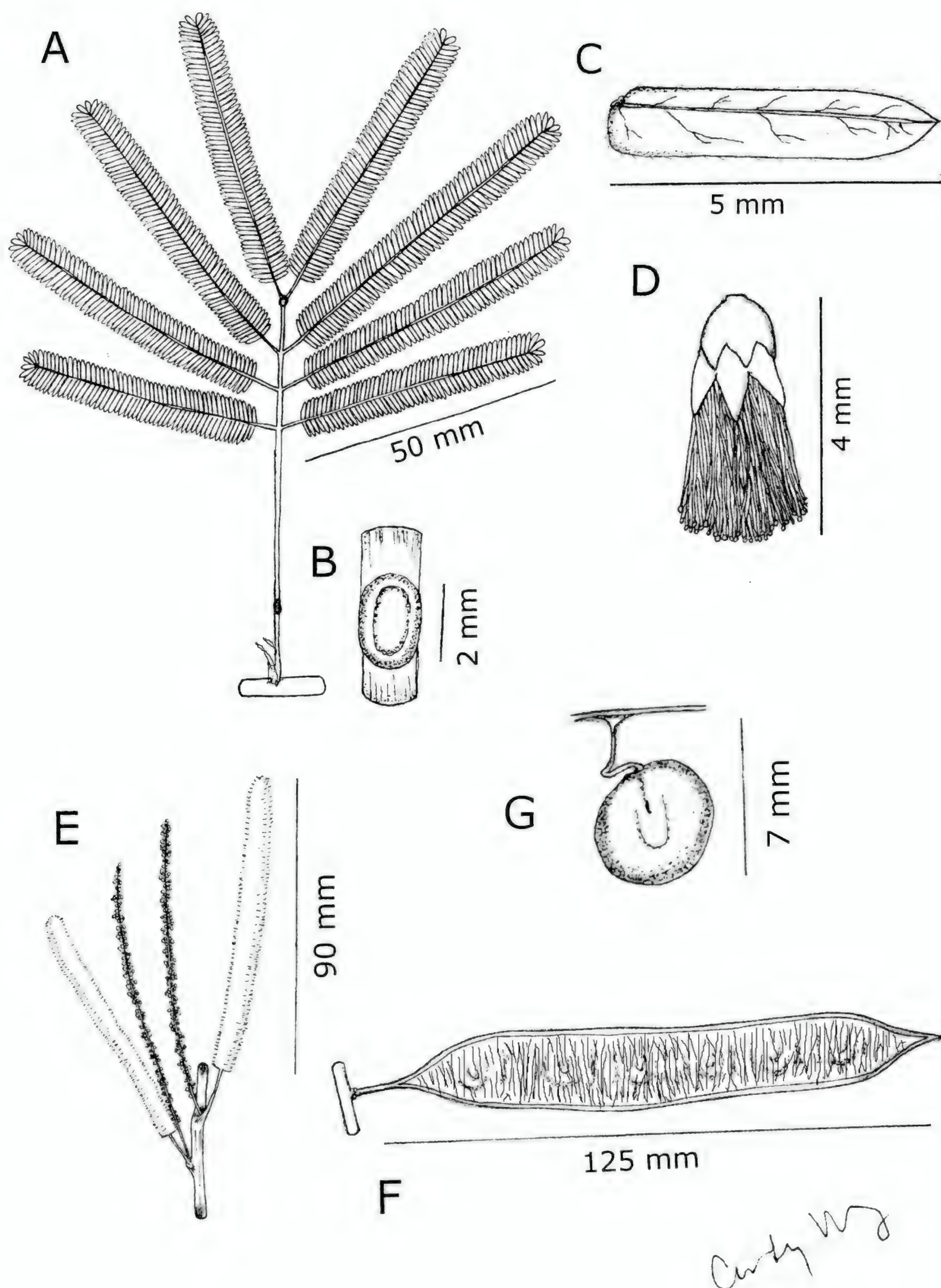


Figure 5. *Mariosousa dolichostachya* (S. F. Blake) Seigler & Ebinger in Seigler et al.; A. Leaf; B. Petiolar gland; C. Leaflet; D. Flower; E. Inflorescences; F. Fruit; G. Seed. A-C from O. Téllez & E. Cabrera 2366 (NY); D, E from R. Durán et al. 85 (MO); F from P. Sima & L. Castillo 1846 (F); G from E. Martínez S. et al. 30879 (MEXU); A-G illustrated by C. Wang.

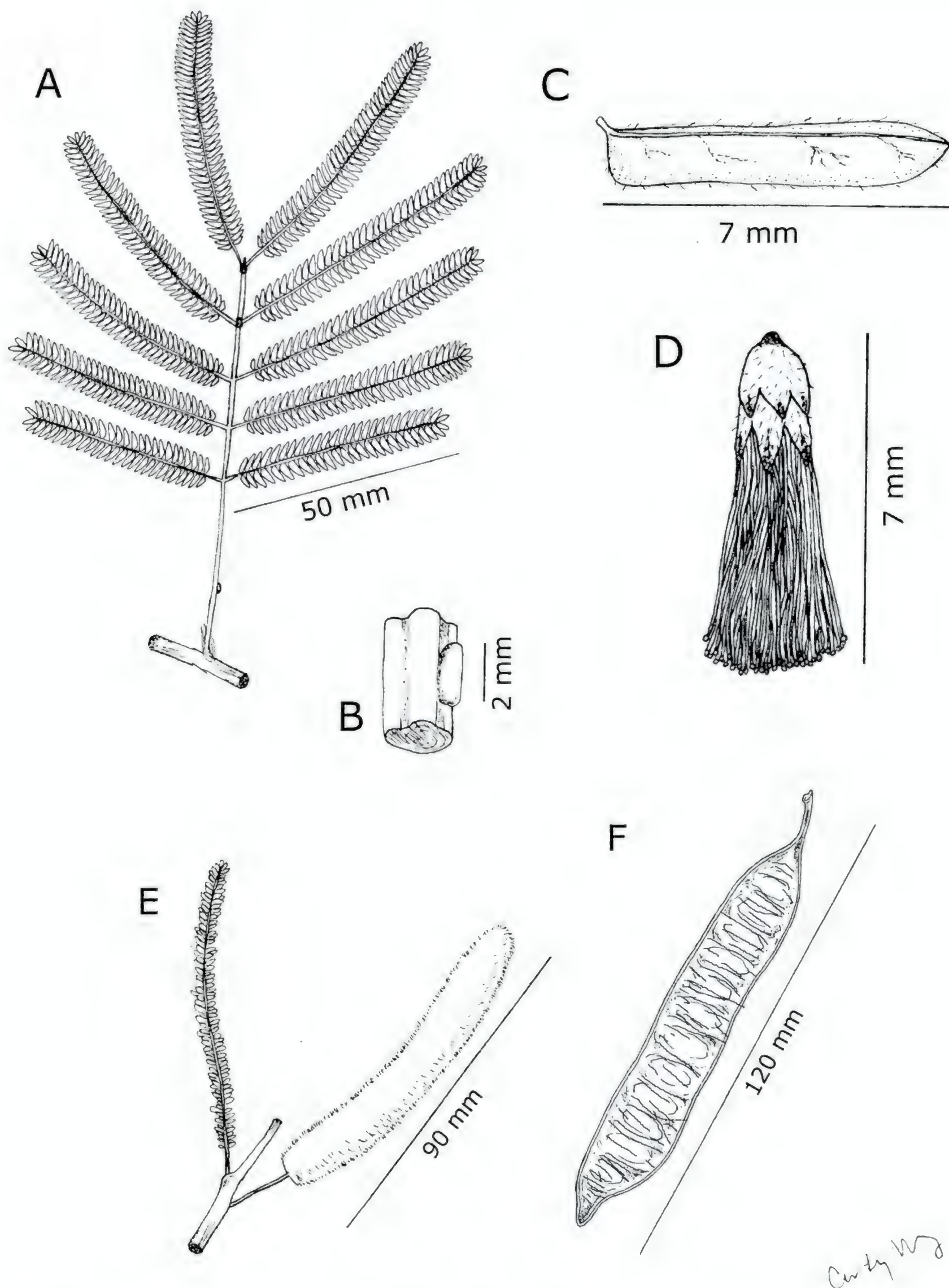


Figure 6. *Mariosousa durangensis* (Britton & Rose) Seigler & Ebinger in Seigler et al.; A. Leaf; B. Petiolar gland; C. Leaflet; D. Flower; E. Inflorescences; F. Fruit. A-C from J. A. S. Magallanes & E. J. Lott. 2903 (MO); D, E from R. Bye et al. 12774 (MEXU); F from P. Tenorio L. et al. 6323 (TEX); A-F illustrated by C. Wang.

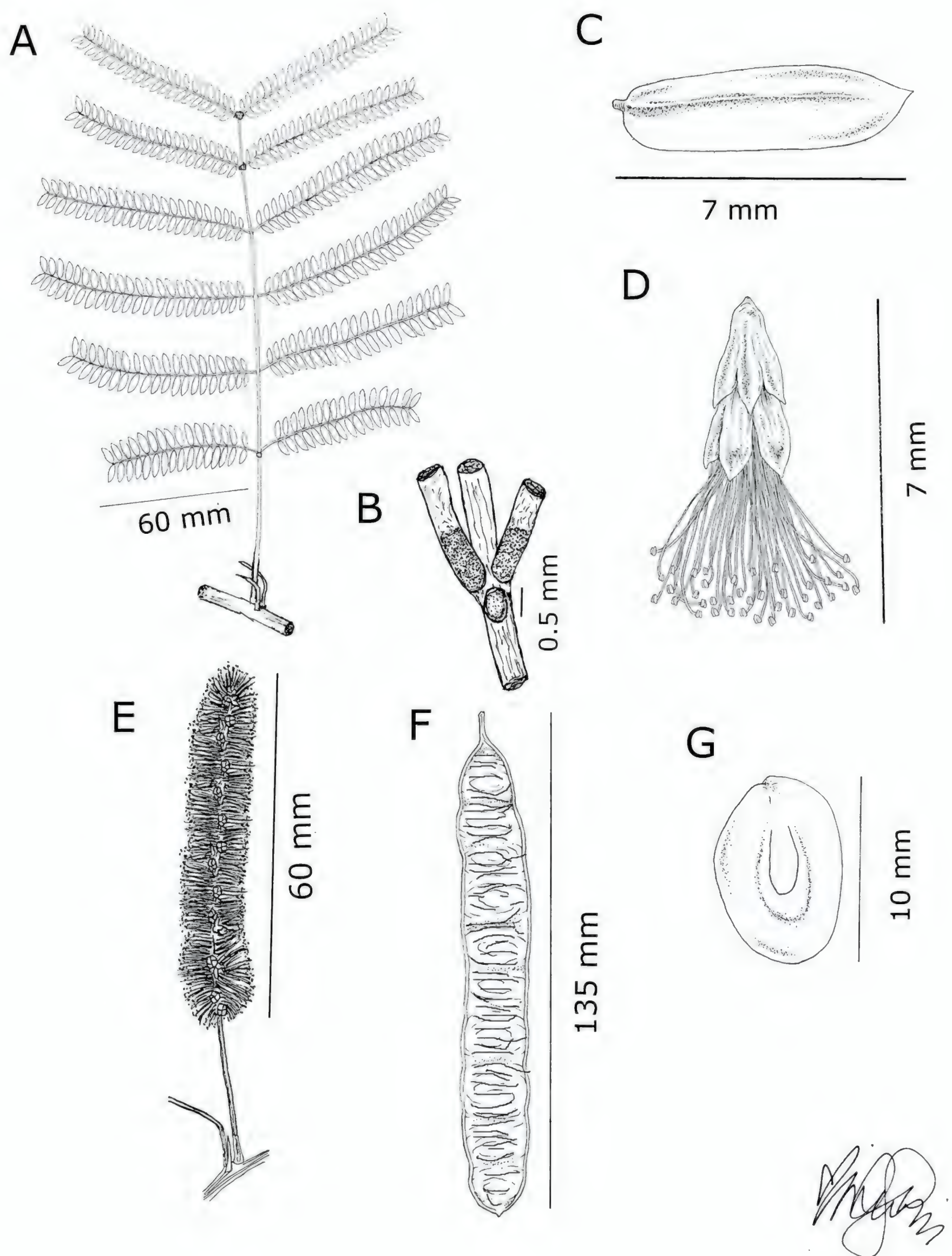


Figure 7. *Mariosousa gentryi* Seigler & Ebinger; A. Leaves; B. Petiolar gland; C. Leaflet; D. Flower; E. Inflorescences; F. Fruit; G. Seed. A-C, F, G from the holotype *H. S. Gentry 14337* (MICH); D, E from *A. C. Gibson & L. C. Gibson 2101* (ASU); A-G illustrated by V. Severini.

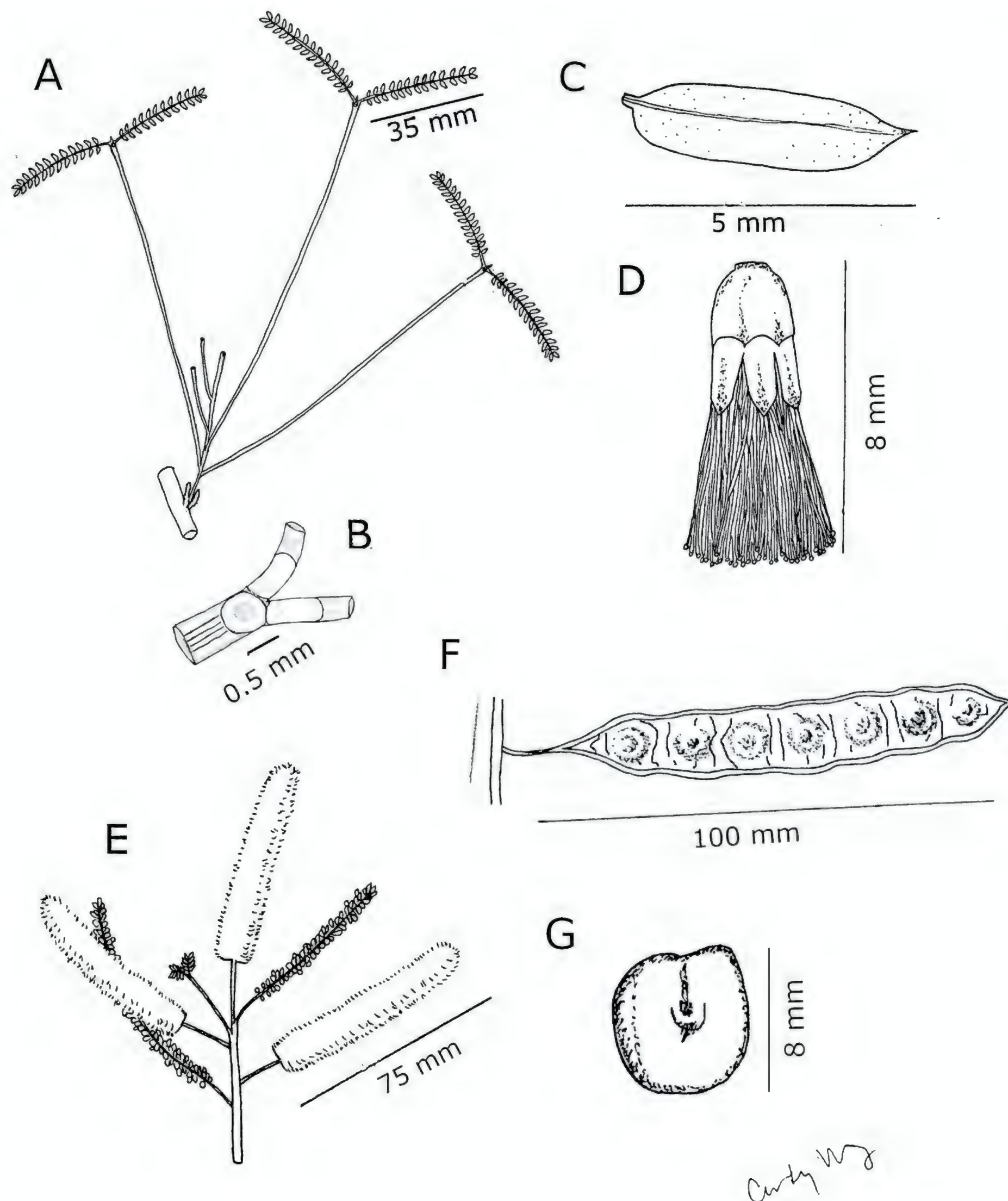


Figure 8. *Mariosousa heterophylla* (Benth) Seigler & Ebinger in Seigler et al.; A. Leaves; B. Petiolar gland; C. Leaflet; D. Flower; E. Inflorescences; F. Fruit; G. Seed. A, B from H. S. Gentry & R. G. Englund 551A (ASU); C from D. J. Pinkava P12788 (ARIZ); D from R. Moran et al. 21940 (ASU); E from G. B. Cummins s. n. (28 Apr 1975) (ARIZ); F from R. Moran 4017 (WIS); G from P. Tenorio L. 9521 (RSA); A-G illustrated by C. Wang.

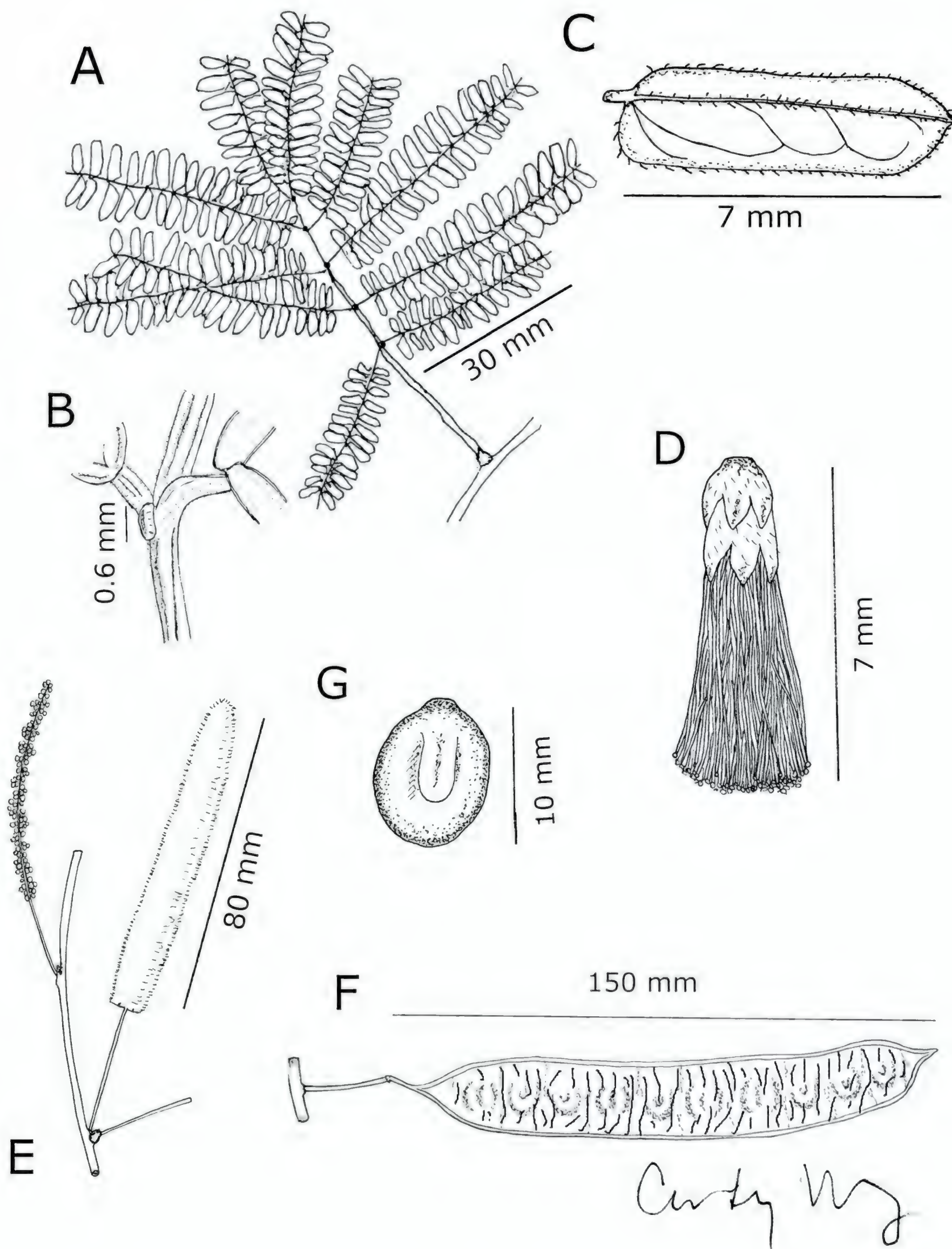


Figure 9. *Mariosousa mammifera* (Schlechtendal) Seigler & Ebinger in Seigler et al.; A. Leaf; B. Petiolar gland; C. Leaflet; D. Flower; E. Inflorescences; F. Fruit; G. Seed. A, C, F, G from K. Roe & E. Roe 2220 (WIS); B from P. Tenorio L. & C. Romero de T. 5777 (WIS); D, E from J. A. Villarreal et al. 2736 (TEX); A-G illustrated by C. Wang.

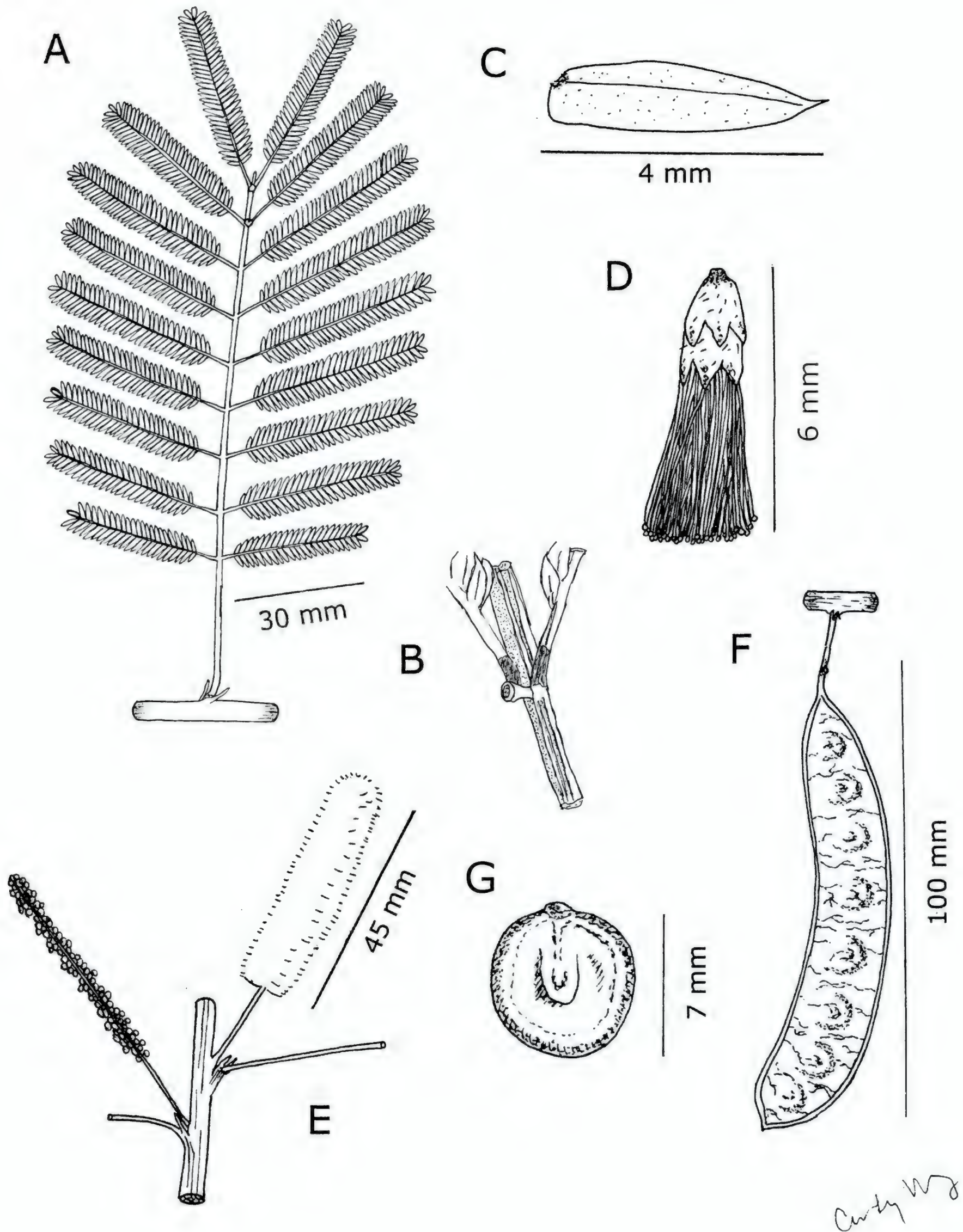


Figure 10. *Mariosousa millefolia* (S. Watson) Seigler & Ebinger in Seigler et al.; A. Leaf; B. Rachis gland; C. Leaflet; D. Flower; E. Inflorescence; F. Fruit; G. Seed. A, B from R. M. Turner & C. H. Lowe Jr. 2062 (ARIZ); C, D from M. Young s. n. (23 Jul 1971) (ASU); E, F from E. Lehto 17858 (ASU); A-F illustrated by C. Wang.

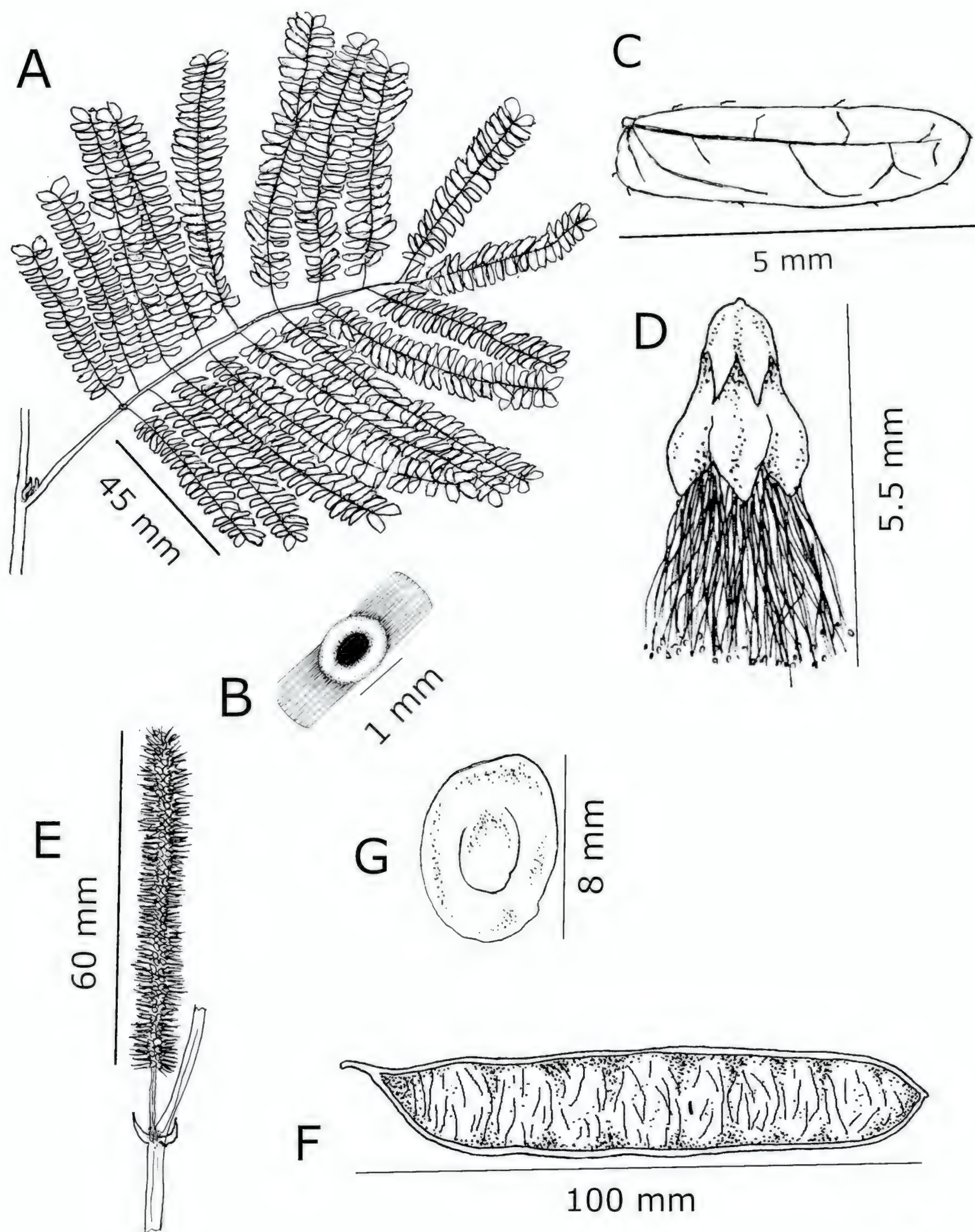


Figure 11. *Mariosousa russelliana* (Britton & Rose) Seigler & Ebinger in Seigler et al.; A. Leaf; B. Petiolar gland; C. Leaflet; D. Flower; E. Inflorescence; F. Fruit; G. Seed. A, C from T. R. Van Devender & C. Lindquist 94-828 (NY); B from I. L. Wiggins & R. C. Rollins 228 (DS), D, E from E. Joyal 2018 (ASU); F, G from P. Tenorio L. et al. 10202 (NY); A-G illustrated by V. Severini.

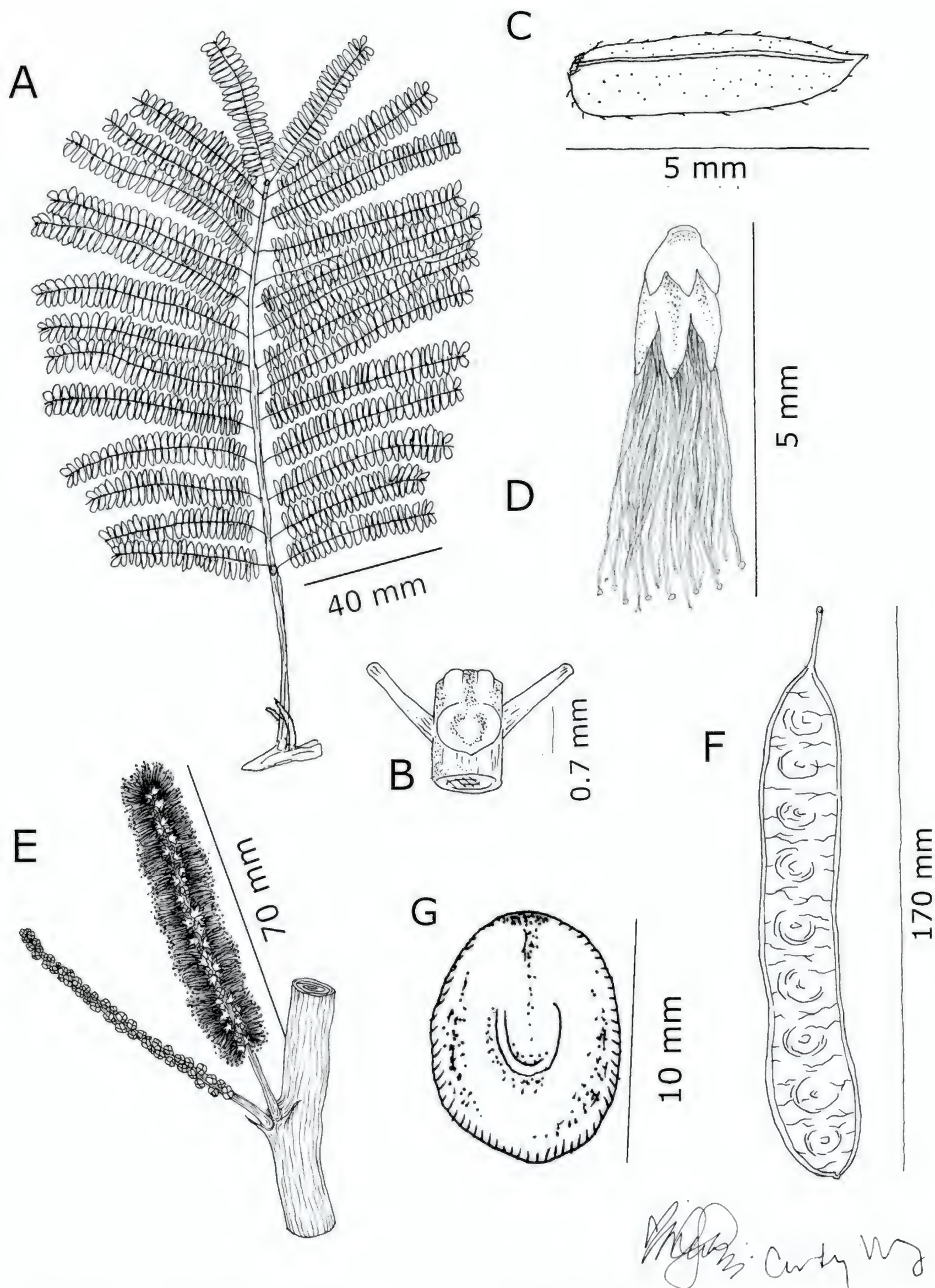


Figure 12. *Mariosousa salazarii* (Britton & Rose) Seigler & Ebinger in Seigler et al.; A. Leaf; B. Petiolar gland; C. Leaflet; D. Flower; E. Inflorescences; F. Fruit; G. Seed. A, F, G from *M. Sousa* 6934 (UC); B, C from *A. Delgado S. & J. García P.* 1085 (WIS); D, E from *V. Jaramillo et al.* F-1175 (MO); A-G illustrated by V. Severini & C. Wang.

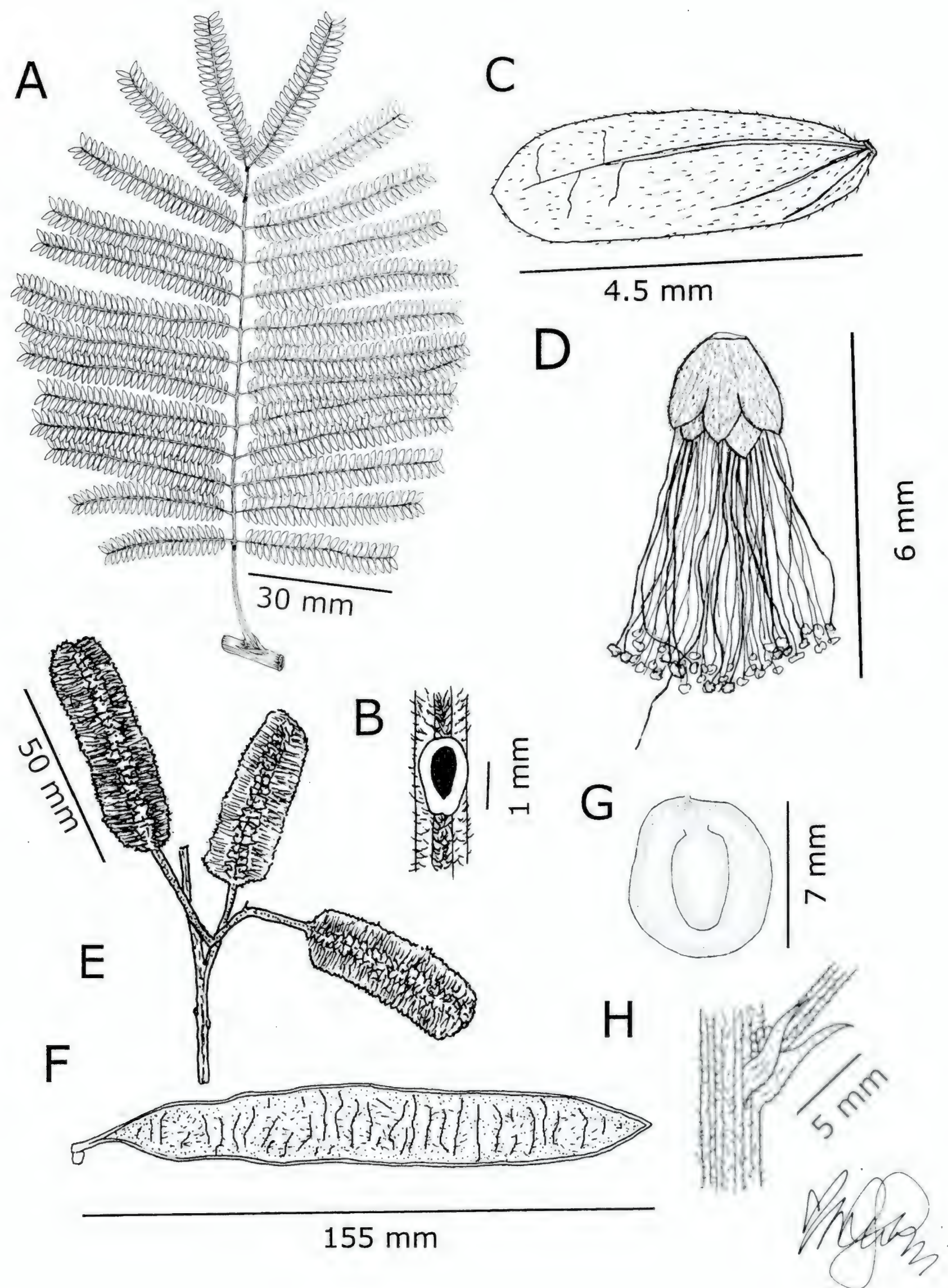


Figure 13. *Mariosousa sericea* (M. Martens & Galeotti) Seigler & Ebinger in Seigler et al.; A. Leaf; B. Petiolar gland; C. Leaflet; D. Flower; E. Inflorescences; F. Fruit; G. Seed; H. Stem with stipules. A, C, D, F, G from *M. Sousa* 6923 (UC); B, E, H from *M. Sousa et al.* 5396 (WIS); A-H illustrated by V. Severini.

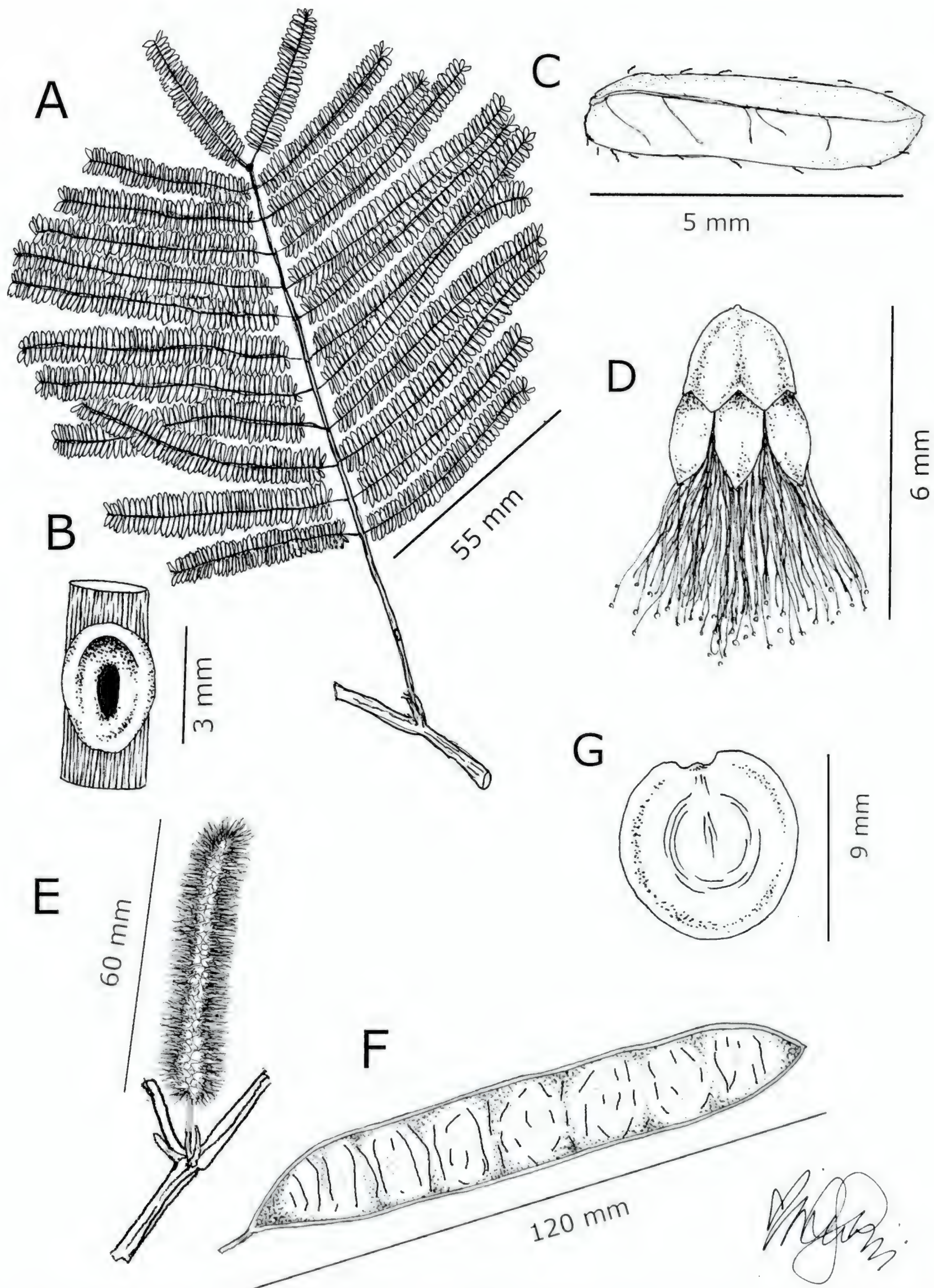


Figure 14. *Mariosousa usumacintensis* (Lundell) Seigler & Ebinger in Seigler et al.; A. Leaf; B. Petiolar gland; C. Leaflet; D. Flower; E. Inflorescence; F. Fruit; G. Seed. A from *E. Contreras* 844 (LL); B from *E. Martínez S. et al.* 30728 (MEXU); C from *E. Contreras* 5869 (LL); D, E from *E. Martínez S. et al.* 30698 (MEXU); F, G from *N. T. Marshall et al.* 423 (NY); A-G illustrated by V. Severini.

Appendix. List of exsiccatae for the *Mariosousa* species examined by the authors during this study. The numbers in parentheses refer to those in the alphabetical and numerical listing of species in the text.

Abrams, L.R. 13340(8).
 Aguilar M., G. 982(14), 7283(14).
 Aguilar M., G. et al. 1907(14).
 Aguilar S., R. 220(1).
 Allen, P.H. & R. Armour, 7257(2).
 Álvarez, A. 5181(5).
 Álvarez, A. & C. Jiménez J. 3289(5), 7384(5).
 Álvarez, D. 5050(14), 5134(14).
 Álvarez, D. & A. Ramírez, 8272(5).
 Anderson, W.R. & C. Anderson, 5332(12).
 Andrieux, G. 396(1).
 Araquistain, M. 3484(2), 3526(2), 3532(2).
 Araquistain, M. & P. Moreno, 1333(2).
 Arvigo, R. et al. 492(14), 828(14), 840(14), 940(14).
 Atchison, E. 427(4).
 Balick, M.J. et al. 1818(14).
 Barr, R.J. 66-199(10), 67-374(10).
 Barrell, J. & S. Spongberg, 66-208(10).
 Bartlett, H.H. 10818(4).
 Benson, L. 8802(10), 9271(10), 11346(10).
 Bermudez, B. 11(2).
 Bezy, R.L. 512(10).
 Blakley, E.R. B-820(8), 1638(8).
 Boege, W. 94(1).
 Boucher, 703(2).
 Bowers, J.E. & S.P. McLaughlin, 1870(10).
 Boyd, S. et al. 6604(12).
 Bradburn, A. & S. Darwin, 1294(5).
 Breckon, G.J. et al. 2278(4).
 Breedlove, D.E. 33387(14).
 Brokaw, N.V.L. 280(14).
 Brown, C.S. IV(14).
 Brown, J.L. & P. Cocon, 56 (14).
 Brunner, D.R. 57(8).
 Bye, R. et al. 12774(6).
 Cabrera, E. 11456(5).
 Cabrera, E. & L. Cortez, 378(5).
 Cabrera, E. et al. 2997(2).
 Cabrera C., E. & H. de Cabrera, 3158(5), 3561(5), 4080(5), 4903(5), 10555(5), 13203(5).
 Calderón, M. et al. 76(2).
 Calderón, S. 1774(2).
 Calzada, J.I. 2385(14).
 Calzada, J.I. & A. Campos, 18320(1).
 Carlson, M.C. 1485(2).
 Carranza, E. 1696(4).
 Carter, A.M. & L. Kellogg, 3246(8).
 Carter, A.M. et al. 71-69(11).
 Castillo, J.J. et al. 2355(14).
 Castillon, A.E.E. 687(9).
 Chan, C. & M. Burgos, 1364(5).
 Chan, C. & E. Ucan, 1023(5).
 Chavarria, U. 461(2).

- Chavelas, J. ES-5504(14).
Chiang C., F. et al. F-1896(1), F-2024(13), F-2466(3), F-2591a(13)
Chimal, A. et al. 755(14), 756(14).
Clark, O.M. 6819(4), 7235(12).
Clausen, R.T. 6036(12).
Clausen, R.T. & J.L. Edwards, 7366(4), 7367(4).
Cochrana, T.S. & F.J. Santana M. 13038(1).
Contreras, E. 844(14), 3467(14), 3599(14), 5479(14), 5869(14), 6987(14), 7089(14), 7349(14), 8356(14), 9198(14).
Contreras, J.L. et al. 6(12).
Conzatti, C. 2046(1), 2176(13), 5321(13).
Cornejo, D.O. 25(12).
Coville, R.V. 1648(8).
Croat, T.B. 23705(14).
Crutchfield, J. & M.C. Johnston, 5390(4), 5401(4), 5425(4), 5514(4).
Daniel, T.F. 2351(8), 3980(8).
Daubenmire, R. 104(2), 775(2).
Davis, L.I. & E. Kincaid, 55-66(12).
Dayton, W.A. & W.R. Barbour, 3099(2).
Deam, C.C. 6281(2).
Delgado S., A. & J. García P. 1085(12).
Delgado S., A et al. 181(1).
Díaz, R. 388(4).
Díaz, R. et al. 484(4).
Dillon, M.O. & E. Rodríguez, 1032(8).
Dorado R., O.R. & A. Salinas, T. F-2776(13).
Durán, R. et al. 85(5), 2197(5), 3038(5), 3351(5).
Dwyer, J.D. 12662(14), 14858(14).
Dwyer, J.D. & R. Coomes, 12930(14).
Dwyer, J. D. et al. 258(5).
Elorsa C., M. 1170(14), 2088(14), 2113(2), 2757(14), 3056(14), 6996(1).
Enríquez E., E.D. 294(1).
Estyrada C., A.E. & S. Favela, 1459(4).
Felger, R.S. 85-38(1), 353(8), 2416(8), 2787(8), 3000(11), 3596(10), 3619(10), 3628(11), 5513(8), 6553(8), 7930(8), 9151B(8), 10047(8).
Felger, R.S. & R.L. Bezy, 14036(8).
Felger, R.S. & E. Hamilton, 15638(8).
Felger, R.S. & C.H. Love, Jr. 2576(8), 2600(8).
Felger, R.S. & F.W. Reichenbacher, 85-1084(11).
Felger, R.S. et al. 02-255(11), 06-86(8), 08-143(8), 74-8(8), 84-204(11), 84-382(10), 85-561(8), 90-694(11), 9989(8), 10023(8), 11588(8), 17725(8).
Ferris, R.S. 10054(10).
Fishbein, M. et al. 926(8).
Flórez-Castorena, F. & R. Ramírez R. 797(5).
Flyr, D. 101D(8).
Friedman, S.L. 029-96(11), 184-93(11).
Friedman, S.L. & G. Hall, 361-93(11).
Friedman, S.L. & K.J. Johnson, 514-49(11).
Friedman, S.L. & J.R. Zittere, 156-95(11).
Friedman, S.L. et al. 256-95(11).
Galeotti, H. 3345(13).
García, M.E. 96(2).
Garnier, A. 957(2).
Gaumer, G.F. 679(5), 1353(5), 1358(5).
Gaumer, G.F. & Sons, 23329(5).
Gentry, H.S. 1473(11), 2190(8), 3012(8), 3784(10), 11432(7), 14309(11), 14337(7), 14420(7), 14483(8), 16560(11), 17635(11).

- Gentry, H.S. & R.G. Englard, 551A(8).
Gibson, A.C. & L.C. Gibson, 2101(7).
Glass, C. & G. Glass, 370(4), 379(4), 442(10).
González, Q., L. 824(9), 2358(4).
González, L. & A. Garita, 2995(2), 3021(2).
Goodding, L.N. A-9814(10), 19-42(10), 89-53(10), 491-58(10), 251-60(10), 2319(10).
Goodding, L.N. & L.E. Goodding, A-9100(10).
Goodman, E.A. 389(8).
Graham, J. & M.C. Johnston, 4096(4).
Grether, R. & H. Quero, 1239(13).
Grether, R. et al. 1331(5).
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A historical collection of *Osmorhiza claytonii* (Apiaceae) from Louisiana

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ABSTRACT

Osmorhiza claytonii is reported for the state of Louisiana based on a specimen collected by Josiah Hale in the 19th century. The locality is vague, but other records from the collector and his contemporaries have been treated as representative of the state's flora. Because no more recent occurrences for this taxon have been reported for the state it should be regarded as historical. *Published online www.phytologia.org Phytologia 105(2): 68-70 (June 21, 2023). ISSN 030319430.*

KEYWORDS: Sweet Cicely, Rapides, Josiah Hale.

While comparing digitized herbarium records to various taxa in a checklist of Louisiana's flora prepared by John Leonard Riddell (1852), I stumbled across a specimen of *Osmorhiza* collected by Josiah Hale which is stored at Brown University (BRU) (Fig. 1). Dr. Hale was a prolific collector in central and northern Louisiana in the mid-19th century (Ewan 1977). He lived at different times near both Alexandria and Shreveport, which are respectively in Rapides and Caddo parishes. Innovative, but bound to his era, Hale made only the simplest annotations on his collection labels (pers. obs.). In the case of the *Osmorhiza*, the date is missing, there is no collection number, and the location is given generically on the stationary of the label. The difficulty of assigning a spatial-temporal fix for his specimens is not new; the issue is discussed in depth by Holmes and Singhurst (2012). In general, it is known that Hale, Riddell, and William Marbury Carpenter were acquainted and painstakingly developed a checklist of Louisiana's flora. After it was rejected for publication by the Smithsonian, the paper was condensed into the work I cite for Riddell (Holmes and Singhurst 2012; Michael MacRoberts unpublished report). The rediscovery of this specimen, and others recently digitized by BRU, supports the claim by Riddell (1852) that nearly all of the plants he catalogued were represented by vouchers.

In Riddell's catalog he lists *O. longistylis*, and the Hale specimen is labeled with the disused name *O. brevistylis* D.C., while the pubescence and location suggest the modern identity as *O. claytonii* (Michx.) C.B. Clarke. *Osmorhiza claytonii*, or hairy sweet cicely, reaches 30-100 cm in height, bears cordlike roots, villous stems and leaves, usually 4-7 flowers in each umbellet of its diffuse inflorescence, and has little if any odor of anise (Small 1933; Weakley 2023; pers. obs.). It inhabits rich woods from Arkansas to the Carolinas and northward to Maine and North Dakota (Kartesz 2014; Small 1933; Weakley 2023). Due to the disjunct nature, the occurrence of this species in Louisiana at first seems unlikely. However, there are many other disjunct northern species such as *Heuchera hirsuticaulis* and *Micranthes virginianensis* with range extensions into this region (Kartesz 2014; Kelley 2021).

The sheet pictured below is the only specimen and the only record of this genus I found for the state aside from its inclusion in Riddell's checklist; it has been roundly excluded by other works (Kartesz 2014; Small 1933; USDA, NRCS 2023; Weakley 2022). Like Holmes and Singhurst, I have decided to report on this issue in hopes that the taxon might be rediscovered in the state. It should be treated as historical, but a careful eye should be trained on the hardwood slopes of the Kisatchie National Forest in Spring.



Figure 1. Record specimen. Copyrighted CC-BY from BRU.
<https://www.brown.edu/research/projects/herbarium>

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Calcareous prairie vegetation of Smith Prairie in Cleburne, Texas

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ABSTRACT

We analyzed a calcareous prairie remnant in the Grand Prairie (GP) ecoregion at Smith Prairie, near Cleburne, Texas and described species composition, biomass, and structure of vegetation. The site had not been grazed by cattle in decades, but because of a Cleburne, Texas, mowing ordinance, it has been mowed several times per year over the decades. Our analysis was conducted to provide baseline knowledge on the natural vegetation of this calcareous prairie in Texas and to provide data to the city of Cleburne that frequent mowing should be terminated to promote prairie succession. The prairie remnant was comprised of two vegetational layers: 1) upper-canopy, mainly along an intermittent stream consisting of a few scattered shrubs and trees including *Celtis laevigata* (sugarberry), *Juniperus asheii* (Ashe's juniper), and *Prosopis glandulosa* (honey mesquite) 2) open areas containing annual and perennial forbs and grasses. The most important forbs were *Biflora Americana* (prairie bishop) and *Salvia texana* (Texas sage). The most important grass was *Schizachyrium scoparium* (little bluestem). Prairie bishop, which is an annual forb, was common in the spring but did not occur in the other seasons. Texas sage and little bluestem, both perennial forbs, were common in all three growing seasons. Live biomass, diversity, and number of exotic species were similar to prairie remnants from the Blackland Prairie, east of the site, which were also dominated by little bluestem but had different forb species. This is the easternmost prairie remnant of the GP that has been analyzed quantitatively and seasonally. Published online www.phytologia.org *Phytologia* 105(3): 71-83 (December 21, 2023). ISSN 030319430.

KEY WORDS: Calcareous prairie remnant, Grand Prairie, Plant community ecology

Greater than 90% of the area once occupied by the tallgrass prairie in North America has been modified for agriculture (Samson & Knopf 1994), resulting in a loss of biodiversity and ecosystem services. Temperate grasslands are among the most modified ecosystems on earth due to their soils and ease of conversion to cropland (Henwood 2010). In the Central Grassland of North America, 21.5 million ha of grassland, an area the size of Kansas, was converted to cropland between 2009 and 2015, with the region losing more habitat in 2014 than the Brazilian Amazon lost to deforestation during that time period (Gage et al. 2016; World Wildlife Fund 2016).

Therefore, description of the natural vegetation is an important phase in understanding and conserving Texas prairie areas. There has been limited description and vegetational analysis of such communities (TPWD 2012). The Blackland Prairie (BP), with gently rolling to nearly level topography and dark calcareous clay soils that developed with prairie vegetation, was the reason most of this region of Texas was put into cultivation. Today, only small acreages of land remain in hay meadows or rangeland with tall grass vegetation in the BP (Correll and Johnston 1979). The BP may be divided into four bands of grassland separated by various mixtures of oak woodland. The San Antonio and Fayette Prairies extend southward with the main arm of the BP extending northward to the Red River along the Oklahoma border (Smeins 2004). The Grand Prairie (GP) is an arm that extends northward between narrow oak woodlands known as the East and West Cross Timbers (Landers 1987). The north-central portion of Texas immediately

south of the Red River consists of alternating, north/south trending belts of rolling prairies, savannas, woodlands, and forests (Smeins 2004). While these zones are in places distinct, the woodlands and prairies often intergrade with one another and form a patchwork mosaic, which captures the meaning of the French derived term "prairie," which implies a rolling grassland with woody plants present or within visual range (Weniger 1984). The GP as viewed by Kendall (1845) was "a prairie region utterly destitute of timber" and "as far as the eye could reach ... nothing could be seen but a succession of smooth, gently undulating prairies." Smythe (1852) described the GP as "prairie, with an occasional strip of woodland," "beautiful groves of Live Oak ... crowning every hill" and "densely tangled cedar ravines." Thus, while generally described as open grassland compared to the Cross Timbers, the GP contained woody elements (Smeins 2003), and, the river bottoms of both regions were typically forested or, at least in most places, had a major woody component (Kendall 1845). Geologic history and resultant landforms and soils distinguish the GP from the BP because this portion of Texas has been variously under epicontinental seas that have produced a great variety of sandstone, limestone, and associated sedimentary substrates (Smeins 2004). The sandy substrates generally occur where the sea margin or coastline persisted for long periods and limestone developed in what were reefs, bays, and lagoons (Hill 1887, 1901). Hill (1901) points out that although often confounded with the BP, the GP differs from it in many physical features. In general, the surfaces are flat rather than undulating and the valley slopes are scarped or terraced, rather than rounded. The residual soils and regolith are shallow in comparison with those of the BP, and are of brown colors instead of black. The chief difference is the underlying limestones (Hill 1901) of the GP. The GP occurs on limestone substrates and the Mollisols derived from them, whereas the Cross Timbers occur on sandy substrates over Alfisols (Godfrey et al. 1973). The GP is generally considered to be the southern extension of the True, Tallgrass, or Bluestem Prairie occurring on limestone-derived Mollisols that are generally rather shallow and rocky (Smeins 2004). According to Elliott et al. (2014), soils of the GP in Texas differ from those of the BP in being browner in color and containing more rock fragments, with soils of this area more frequently characterized as Mollisols, as opposed to the Vertisols more characteristic of the BP.

Diggs et al. (1999) describe the GP as a vegetational region composed of the Fort Worth Prairie to the north of the Brazos River and the Lampasas Cut Plain to the south. The GP roughly corresponds to the Comanche Plateau, a region related geologically to the Edwards Plateau to the south but from which the limestones of the Edwards Formation have in large part been eroded away, exposing older Cretaceous formations in a dissected landscape (Hill 1901; Fenneman 1931; Stephens & Holmes 1989). The most significant of these strata from the standpoint of vegetation structure and endemism are the Walnut Formation and Glen Rose Formation (Locklear 2017). These are composed of erosion-resistant limestones beds and less consolidated strata termed marl, clay, or shale, creating a diversity of habitats including barrens, glades, and seeps that supports small communities of herbaceous vegetation within the surrounding juniper-oak or oak woodland/savanna and grassland that have been called Reverchon Rocklands (Locklear 2017). The distinctiveness of the flora and vegetation of the GP has long been recognized (Hill 1901; Dyksterhuis 1946; Diamond & Smeins 1985; Smeins 2004) but little quantitative work has been produced for the GP.

We conducted this investigation to provide descriptions and analyses of calcareous prairies of the GP (Diggs et al. 1999). Currently there is a need for quantitative data of this vegetation type, which is lacking for much of Texas (Diamond et al. 1985) and because of ongoing classification and ground-truthing of natural plant communities (Elliott 2013), as well as prairie reclamation and restoration projects.

MATERIALS AND METHODS

The study area was within the GP ecoregion (Diggs et al. 1999) and Cross Timbers and Prairies vegetational area (Correll and Johnston 1979) in Johnson County, Texas (Figure 1). The site had not been grazed by cattle in decades but has been mowed once or twice per year for decades, is about 4.5 ha in size and privately owned by the Smith family in Cleburne, Texas. It is referred to as Smith Prairie and is located

at 32.3471010, -97.4342060. The GP ecoregion lies just to the west and north of the BP ecoregion in Texas, and is typified by the area between Fort Worth and Decatur (Texas Parks and Wildlife Department (TPWD) 2012). The vegetation is very similar to that of the BP, but the soils are generally shallower and the rainfall averages are less than the BP (TPWD 2012). The general soil map unit is Aledo-Bolar on a ridgetop, which are shallow to moderately deep with limestone fragments and slopes of 1-8% with the soil surface consisting of dark, grayish brown clay loam with 10% limestone fragments by volume overlaying a gravelly clay loam that is about 75% limestone fragments by volume (Coburn 1985).



Figure 1. Map of Texas showing the location of Johnson County. The site is near the city of Cleburne at 32.3471010, -97.4342060.

The Texas Native Prairie Remnant Project forms (Texas Master Naturalist, Gideon Lincecum Chapter 2009) were used to define the area as a prairie remnant and a list of species encountered, while conducting the survey is included in Table 1. To obtain quantitative data, transects that were 50 m in length were aligned N-S and E-W and crossed at 25 m. Random numbers were generated for each 25 m segment for the four cardinal directions. Using these random sites, we clipped aboveground biomass at Smith Prairie to 2 cm height in each of 12 plots (0.71 x 0.71 m; total area of 0.5 m²; Polley et al. 2005). Samplings were taken in summer, spring and fall of 2019-2021 (Table 2) for a total of 6.0 m² sampled over the time of the investigation. Live (green) tissue removed from each sample was separated by species, dried to constant mass at 60°C, and then weighed as done by Polley et al. (2005) for three BP remnants.

Table 1. Plants observed using Texas Native Prairie Remnant Project form listed alphabetically by family, and scientific name (Diggs et al. 1999). Common names are in parentheses.

Agavaceae	<i>Yucca pallida</i> (pale yucca)
Apiaceae	<i>Biflora americana</i> (prairie-bishop)
	<i>Polytaenia nuttallii</i> (prairie-parsley)
	<i>Treprocarpus aethusae</i> (treprocarpus)
Asclepiadaceae	<i>Asclepias</i> spp. (milkweeds)
Asteraceae	<i>Ambrosia psilostachys</i> (western ragweed)
	<i>Arnoglossum plantagineum</i> (prairie plantain)

	<i>Aster</i> sp. (aster)
	<i>Centaurea americana</i> (American basketflower)
	<i>Cirsium texanum</i> (Texas thistle)
	<i>Crepis pulchra</i> (showy hawk's-beard)
	<i>Engelmannia peristema</i> (Engelmann's daisy)
	<i>Gaillardia pulchella</i> (fire-wheels)
	<i>Gutierrezia amoena</i> (broomweed)
	<i>Liatris</i> sp. (gayflower)
	<i>Lindheimeri texana</i> (Texas star)
	<i>Marshallia caespitosa</i> (Barbara's-buttons)
	<i>Rudbeckia</i> sp. (coneflower)
	<i>Silphium albiflorum</i> (white rosinweed)
	<i>Symphyotricum ericoides</i> (heath aster)
	<i>Tetraneuris scaposa</i> (Plains yellow daisy)
	<i>Thelesperma filifolium</i> (greenthread)
Cactaceae	<i>Opuntia</i> spp. (pricklypear cactus)
Commelinaceae	<i>Commelina erecta</i> (widow's tear)
	<i>Tradescantia</i> sp. (spiderwort)
Cupressaceae	<i>Juniperus asheii</i> (Ashe's juniper)
Cuscutaceae	<i>Cuscuta indecora</i> (showy dodder)
Euphorbiaceae	<i>Croton michauxii</i> (narrow-leaf rushfoil)
	<i>Phyllanthus polygonoides</i> (knotweed leaf-flower)
	<i>Tragia ramosa</i> (catnip noseburn)
Fabaceae	<i>Desmanthus illinoensis</i> (Illinois bundleflower)
	<i>Lupinus texensis</i> (Texas bluebonnet)
	<i>Prosopis glandulosa</i> (honey mesquite)
	<i>Vicia ludoviciana</i> (deer pea vetch)
Iridaceae	<i>Herbertia lahue</i> (herbertia)
	<i>Sisyrinchium angustifolium</i> (Bermuda blue-eyed-grass)
Krameriaceae	<i>Krameria lanceolata</i> (trailing ratany)
Lamiaceae	<i>Hedeoma reverchonii</i> (rock hedeoma)
	<i>Salvia texana</i> (Texas sage)
	<i>Scutellaria drummondii</i> (Drummond's skullcap)
	<i>Warnockia scutellarioides</i> (prairie Brazoria)
Liliaceae	<i>Nothoscordum bivalve</i> (crow poison)
Linaceae	<i>Linum</i> sp. (flax)
Onagraceae	<i>Calylophus berlandieri</i> (half-shrub sundrops)
	<i>Gaura</i> sp. (gaura)
	<i>Oenothera</i> sp. (primrose)
Oxalidaceae	<i>Oxalis corniculata</i> (creeping ladies'-sorrel)
Plantaginaceae	<i>Plantago</i> sp. (plantain)
	<i>Plantago helleri</i> (cedar plantain)
Poaceae	<i>Andropogon gerardii</i> (big bluestem)
	<i>Aristida purpurea</i> (purple threeawn)
	<i>Bouteloua hirsuta</i> (hairy grama)
	<i>Bouteloua pectinata</i> (tall grama)
	<i>Bromus japonicus</i> (Japanese brome)
	<i>Buchloe dactyloides</i> (buffalograss)
	<i>Cynodon dactylon</i> (Bermudagrass)
	<i>Elymus canadensis</i> (Canada wildrye)
	<i>Muhlenbergii reverchonii</i> (Reverchon's muhly)

	<i>Nasella leuchotricha</i> (needlegrass)
	<i>Panicum virgatum</i> (switchgrass)
	<i>Schizachyrium scoparium</i> (little bluestem)
	<i>Sorghastrum nutans</i> (Indiangrass)
	<i>Sorghum halapense</i> (Johnsongrass)
	<i>Sporobolus compositus</i> (tall dropseed)
Polygonaceae	<i>Eriogonum annuum</i> (annual buckwheat)
Ranuncleaceae	<i>Anemone berlandieri</i> (Berlandier's anemone)
Rubiaceae	<i>Hedyotis nigricans</i> (prairie bluets)
	<i>Sherardia arvensis</i> (field-madder)
Sapotaceae	<i>Sideroxylon lanuginosum</i> (bumelia)
Scrophulariaceae	<i>Castilleja purpurea</i> (purple paintbrush)
Ulmaceae	<i>Celtis laevigata</i> (sugarberry)

We calculated density (plants/m²), frequency, and importance values obtained by adding density and frequency, and dividing by two (Brower et al. 1997). Relative importance values (%) are reported (Table 3; Brower et al. 1997). Biomass, exotic species, and Simpson diversity indexes, richness, and evenness (Polley et al. 2005) as well as Shannon diversity were examined (Table 4). Shannon diversity indexes, richness, and evenness were calculated according to formulas in Ludwig and Reynolds (1988).

Species of plants were identified and classified using Diggs et al. (1999), which also served as the reference for common and scientific names. We deposited voucher specimens in the herbarium (TAC) at Tarleton State University in Stephenville, Texas.

RESULTS

Twenty-five families were observed at Smith’s Prairie with the sunflower and grass families having the most species (Table 1). *Biflora americana* (prairie bishop), which is an annual forb was common in the spring but did not occur in the other seasons (Table 2). *Salvia texana* (Texas sage) and *Schizachyrium scoparium* (little bluestem), both perennials, were common in all three growing seasons (Table 2).

Biomass was about the same in the summer and fall seasons but dropped in the spring samples, which had the highest amounts of litter (Table 2). The most important forbs were prairie bishop and Texas sage (Table 3). The most important grass was little bluestem (Table 3). Live biomass, diversity, and number of exotic species were similar to prairie remnants from the BP (Table 4), which were east of the site and also dominated by little bluestem but had different forb species.

Table 2. Species arranged alphabetically, biomass (g), and number of individuals for Smith’s Prairie remnant over three samples. Introduced, exotic species are indicated with an asterisk (*).

Sample 1 (2.0 m ²)	Summer	June 1, 2020
Species (29 total)	Biomass (g)	Individuals
<i>Anemone berlandieri</i>	0.5	4
<i>Aristida purpurea</i>	0.41	5
<i>Biflora americana</i>	38.7	299
<i>Bouteloua hirsuta</i>	0.16	1
<i>Bouteloua pectinata</i>	80.4	50
<i>Calylophus berlandieri</i>	3.50	27
<i>Castilleja purpurea</i>	14.03	20
<i>Croton michauxii</i>	0.81	17

<i>Cuscuta indecora</i>	0.10	1
<i>Eriogonum annuum</i>	0.05	1
<i>Gaillardia pulchella</i>	5.30	21
<i>Hedeoma reverchonii</i>	1.50	8
<i>Hedyotis nigricans</i>	3.69	25
<i>Krameria lanceolata</i>	28.38	169
<i>Linum</i> sp.	0.32	8
<i>Lupinus texensis</i>	0.16	1
<i>Marshallia caespitosa</i>	0.60	1
<i>Phyllanthus polygonoides</i>	0.25	14
<i>Plantago</i> sp.	2.81	9
<i>Plantago helleri</i>	0.50	8
<i>Polytaenia nuttallii</i>	1.33	24
<i>Salvia texana</i>	351.30	55
<i>Schizachyrium scoparium</i>	10.40	29
<i>Sherardia arvensis</i> *	0.03	2
<i>Sisyrinchium angustifolium</i>	0.41	6
<i>Tetraneuris scaposa</i>	1.43	4
<i>Thelesperma filifolium</i>	0.59	9
<i>Tragia ramosa</i>	0.70	2
<i>Warnockia scutellarioides</i>	1.60	39
Unknown specimens	2.76	46
Total Biomass	552.72	
Litter	160.6	
Sample 2 (2.0 m²)	Fall	October 5, 2020
Species (12 total)	Biomass (g)	Individuals
<i>Bouteloua hirsuta</i>	4.6	37
<i>Bouteloua pectinata</i>	2.51	2
<i>Croton michauxii</i>	0.44	3
<i>Guitierrezia amoena</i>	6.00	40
<i>Hedeoma reverchonii</i>	0.50	8
<i>Herbertia lahue</i>	0.43	1
<i>Linum</i> sp.	0.52	4
<i>Salvia texana</i>	497.70	24
<i>Schizachyrium scoparium</i>	77.0	59
<i>Scutellaria drummondii</i>	0.27	4
<i>Thelesperma filifolium</i>	0.56	1
<i>Tragia ramosa</i>	0.55	8
Unknown specimens	3.75	5
Total biomass	594.83	
Litter	212.8	
Sample 3 (2.0 m²)	Spring	April 17, 2021
Species (24 total)	Biomass (g)	Individuals
<i>Bouteloua pectinata</i>	1.27	6
<i>Bromus japonicus</i> *	2.74	57
<i>Calylophus berlandieri</i>	6.96	13
<i>Castilleja purpurea</i>	1.98	1
<i>Crepis pulchra</i> *	0.01	1

<i>Engelmannia peristema</i>	2.27	5
<i>Eriogonum annuum</i>	2.96	4
<i>Gaillardia pulchella</i>	6.17	67
<i>Hedeoma reverchonii</i>	0.01	2
<i>Marshallia caespitosa</i>	11.28	12
<i>Muhlenbergii reverchonii</i>	5.07	8
<i>Oxalis corniculata</i>	0.02	2
<i>Salvia texana</i>	105.51	227
<i>Schizachyrium scoparium</i>	37.6	23
<i>Scutellaria drummondii</i>	0.96	7
<i>Sida arvensis</i> *	0.02	6
<i>Sisyrinchium angustifolium</i>	0.05	2
<i>Tragia ramosa</i>	0.61	7
<i>Treprocarpus aethusae</i>	1.42	3
<i>Thelesperma filifolium</i>	1.52	15
<i>Vicia ludoviciana</i>	0.36	3
Unknown sedge	1.07	4
Unknown dicot	0.66	8
Unknown mint	3.74	37
Total biomass	194.32	
Litter	633.94	

Table 3. Scientific names of species, density, frequency, and relative importance values (IV) for species at Smith Prairie remnant. An asterisk indicates an introduced, exotic species. Species are arranged from greatest to least importance values

Species names	Density (D; individuals/m ²)	Frequency (F; species sampled/ Total samples)	Importance Value (IV; D+F/2)	Relative IV (%)
<i>Salvia texana</i>	51	1.00	26.00	19.52
<i>Biflora americana</i>	49.83	0.33	25.10	18.84
<i>Krameria lanceolata</i>	28.17	0.33	14.25	10.70
<i>Schizachyrium scoparium</i>	18.5	1.00	9.75	7.32
<i>Gaillardia pulchella</i>	14.67	0.67	7.67	5.76
<i>Bouteloua pectinata</i>	9.67	1.00	5.34	4.01
<i>Bromus japonicus</i> *	9.5	0.33	4.92	3.69
<i>Eriogonum annuum</i>	0.83	0.67	0.75	0.56
<i>Marshallia caespitosa</i>	2.17	0.67	1.42	1.07
<i>Anemone berlandieri</i>	0.67	0.33	0.50	0.38
<i>Sisyrinchium angustifolium</i>	1.33	0.67	1.00	0.75
<i>Calylophus berlandieri</i>	6.67	0.67	3.67	2.76
<i>Gutierrezia amoena</i>	6.67	0.33	3.5	2.63
<i>Warnockia scutellarioides</i>	6.5	0.33	3.42	2.57
<i>Thelesperma filifolium</i>	4.17	1.00	2.59	1.94
<i>Hedyotis nigricans</i>	4.17	0.33	2.25	1.69
<i>Polytaenia nuttallii</i>	4.0	0.33	2.17	1.63
<i>Castilleja purpurea</i>	3.5	0.67	2.09	1.57
<i>Croton michauxii</i>	3.33	0.67	2.00	1.50

<i>Hedeoma reverchonii</i>	3.0	1.0	2.0	1.50
<i>Tragia ramosa</i>	2.00	1.00	1.5	1.13
<i>Linum</i> sp.	2.00	0.67	1.34	1.00
<i>Phyllanthus polygonoides</i>	2.33	0.33	1.33	1.0
<i>Scutellaria drummondii</i>	1.83	0.67	1.25	0.94
<i>Sida arvensis</i> *	1.33	0.67	1.00	0.75
<i>Plantago</i> sp.	1.5	0.33	0.92	0.69
<i>Muhlenbergii reverchonii</i>	1.33	0.33	0.83	0.62
<i>Plantago helleri</i>	1.33	0.33	0.83	0.62
<i>Aristida purpurea</i>	0.83	0.33	0.58	0.44
<i>Engelmannia peristema</i>	0.83	0.33	0.58	0.44
<i>Tetrameura scaposa</i>	0.67	0.33	0.50	0.38
<i>Treprocarpus aethusae</i>	0.50	0.33	0.42	0.32
<i>Vicia ludoviciana</i>	0.50	0.33	0.42	0.32
<i>Oxalis corniculata</i>	0.33	0.33	0.33	0.25
<i>Crepis pulchra</i> *	0.17	0.33	0.25	0.19
<i>Cuscuta indecora</i>	0.17	0.33	0.25	0.19
<i>Herbertia lahue</i>	0.17	0.33	0.25	0.19
<i>Lupinus texensis</i>	0.17	0.33	0.25	0.19
Total			133.2	100.05

Table 4. Live biomass (g/ m²), Simpson's species diversity, species richness, number of exotics, percentage of exotic biomass, Simpson's evenness, Shannon diversity, and Shannon's evenness at the Smith Prairie remnant compared to remnants in the BP. When data was not available, N/A is used.

Prairie Names:	Smith Prairie remnant	Farmersville Prairie remnant (Polley et al. 2005)	Riesel Prairie remnant (Polley et al. 2005)	Temple Prairie remnant (Polley et al. 2005)
Live biomass (BM) (g/m ²)	261.0	290.1	217.4	158.0
Simpson's species diversity	8.84	12.70	5.60	9.00
Species richness	37	43	41	42
Number of exotic species	2	4	3	2
Exotic species (% BM)	3.46	9.20	0.50	< 0.10
Simpson's species evenness	0.24	0.30	0.14	0.21
Shannon diversity	2.67	N/A	N/A	N/A
Shannon's species evenness	0.75	N/A	N/A	N/A

DISCUSSION

Bruner (1931) found that little bluestem was the principal climax species in Oklahoma. A general increase of little bluestem may be expected to be accompanied by a general increase of perennial forbs with increases of *Bouteloua gracilis* (hairy grama) and *B. curtipendula* (sideoats grama) on shallow soils and of *Andropogon gerardii* (big bluestem) and *Sorghastrum nutans* (Indiangrass) on deep soils of the Fort Worth Prairie (Dyksterhuis 1946). Based on our limited data from this investigation, it appears safe to conclude that little bluestem originally constituted two-thirds of the understory vegetation of uplands in the Western Cross Timbers (Dyksterhuis 1948) and the GP. Samples of relicts of the Fort Worth Prairie to the east by Dyksterhuis (1946) had essentially the same percentage of little bluestem as our investigation to the west in the GP. Species more frequent in a calcareous grassland mosaic near Austin, Texas, included forbs such as *Hedyotis nigricans* (prairie bluets), *Ambrosia psilostachys* (western ragweed), *Plantago* spp. (plantains), *Aster* (aster), and *Sisyrinchium* (blue-eyed-grasses) with the dominant grass being little bluestem (Lynch, 1962). This investigation south of our study site on calcareous soil contained similar forb species to those found at Smith Prairie.

Dominant species reported from the BP according to Correll and Johnston (1979) include little bluestem, big bluestem, yellow Indian grass, *Panicum virgatum* (switch grass), side-oats grama, hairy grama, *Sporobolus compositus* (tall dropseed), and *Bothriochloa laguroides* ssp. *torreyana* (silver bluestem). With heavy grazing, *Nasella leuchotricha* (needlegrass), *Buchloe dactyloides* (buffalo grass), *Bouteloua* spp. (gramas), and many annual species become abundant (Correll and Johnston 1979). Using a variety of analyses, a community type termed the *Schizachyrium* type on Mollisols of the Fort Worth Prairie was defined using data from Dyksterhuis (1946) and from 34 other relicts in Texas (Diamond and Smeins 1985). Our prairie remnant was dominated by little bluestem and was similar to the *Schizachyrium* type on Mollisols described by Diamond and Smeins (1985). Also in 1985, Coburn discussed the range type for this area near Cleburne, Texas as a climax of mid and tall grasses interspersed with an abundance of forbs. The range site was described as having 45% little bluestem with 15% Indiangrass, big bluestem, and switchgrass. Other grasses that we identified on Smith Prairie, such as sideoats grama, tall dropseed, hairy grama, buffalograss, and Texas wintergrass as well as forbs found at Smith Prairie such as *Engelmannia peristema* (Engelmann's daisy), aster, *Guara* spp. (guara), and *Liatris* spp. (gayfeather) comprised the rest of the description (Coburn 1985).

Smeins (2004) described late-successional communities of the GP that were characterized by little bluestem, big bluestem, Indiangrass, and switchgrass. Midgrasses including sideoats grama, *Nasella leuchotricha* (needlegrass), tall dropseed, silver bluestem, and hairy grama may be important on shallow soils or may increase as grazing intensity increases (Smeins 2004). Woody species are usually in low abundance, particularly where fire is a frequent influence; however, *Quercus* spp. (oak), *Celtis laevigata* (sugarberry), and *Prosopis glandulosa* (honey mesquite) are commonly found locally across the grassland (Smeins 2004). Elliott (2013) and Elliott et al. (2009-2014) reported that little bluestem tends to dominate sites of this system, with sideoats grama as another significant component. At Smith Prairie, sideoats grama was a minor component and was not sampled in our quantitative portion of the investigation. Other grasses that were frequently present include needlegrass, silver bluestem, *Aristida* spp. (threeawn), big bluestem, buffalograss, tall dropseed, hairy grama, Indiangrass, *Muhlenbergii* spp. (muhly), *Chloris verticillata* (tumble windmillgrass), and *Erioneuron pilosum* (hairy tridens) as well as forb species such as *Symphyotrichum ericoides* (heath aster), western ragweed, *Tragia ramosa* (catnip noseburn), *Amphiachyris dracunculoides* (common broomweed), *Dyschoriste linearis* (narrowleaf dyschoriste), Texas sage, evening primroses (*Oenothera* spp.), prairie bluets, *Thelesperma* spp. (greenthread), *Dalea* spp. (prairie clover), and *Psoralidium* spp. (scurfpea) may be encountered (Elliott 2013; Elliott et al. 2009-2014). At our site, we observed all of these except silver bluestem, tumble windmillgrass, hairy tridens, heath aster, common broomweed, narrowleaf dyschoriste, prairie clover, and scurfpea. We identified a different species of aster

and broomweed at the site. Overall, our site description closely matched that of Elliott (2013) and Elliott et al. (2014).

The most important forbs at Smith Prairie were prairie bishop and Texas sage. The most important grass was little bluestem which is common in prairie relicts (Dyksterhuis 1946; Launchbaugh 1955). Other important grasses and forbs (%IV >4.00) included *Bouteloua pectinata* (tall grama) and *Gaillardia pulchella* (fire-wheels). Prairie bishop, an annual herb on limestone prairies, slopes, and roadsides (Diggs et al. 1999) was the dominant forb along with Texas sage. Texas sage is a perennial herb on limestone prairies and outcrops (Diggs et al. 1999), like the limestone substrate at Smith Prairie. Little bluestem is a perennial grass that is often a vegetational dominant in north Texas prairies (Diggs et al. 1999) and tall grama is another perennial grass that occurs on well drained calcareous soils on hills and outcrops (Diggs et al. 1999). Fire-wheels are perennial forbs (Diggs et al. 1999) that occur in prairies and disturbed areas (Diggs et al. 1999).

Endemic species found in our investigation, limited to or primarily centered in the GP (Locklear 2017) include white rosinweed (*Silphium albiflorum*) and pale yucca (*Yucca pallida*), both of which occur throughout the GP region and overlapping into the Edwards Plateau (Locklear 2017). A number of species are strongly associated with rock outcrop communities in the GP and were found during our investigation, but range more widely (Locklear 2017), including tall dropseed, *Hedeoma reverchonii* (rock hedeoma), *Marshallia caespitosa* (Barbara's-buttons), and *Muhlenbergia reverchonii* (Reverchon's muhly). Exotic species were also sampled at Smith Prairie and TPWD (2012) lists *Cynodon dactylon* (Bermudagrass) as a problematic exotic, but did not mention *Bromus japonicus* (Japanese brome) or *Sorghum halepense* (Johnsongrass), which are also prairie invaders. All three of these exotic grasses occurred at Smith Prairie with Japanese brome becoming common in the spring (Table 2) and Bermudagrass and Johnsongrass occurring on prairie fringes, primarily near the homesite and roadsides near the study site.

Perennial forbs, with a coverage of 8.21 percent and frequency of 100%, were of great significance in the relict vegetation of the Fort Worth Prairie and annual grasses and forbs were both progressively displaced by perennial grasses and forbs (Dyksterhuis 1946). Forbs were more important than grasses at Smith Prairie and this trend is explained by the following. A definite trend in composition of decreaser, increaser, and invader grasses occurred on various study areas as vegetation retrogression occurred as was reported by Sims and Dwyer (1964). The decreasers, little bluestem, big bluestem, Indiangrass, and switchgrass comprised 93 percent of the grasses in the study area that was managed properly and declined to 0% in those that were overgrazed (Sims and Dwyer 1964). Of the species of increaser grasses reported by Sims and Dwyer (1964), only sideoats grama, hairy grama, and tall dropseed increased in overgrazed sites. Forbs were important in many of their study areas and western ragweed tended to increase with a decline in grassland condition (Sims and Dwyer 1964). Annual and total forb species numbers increased in most cases under progressively heavier grazing with annual forbs appearing to react to seasonal weather changes and grazing practices more quickly than the grasses (Sims and Dwyer 1964). Disturbance caused by mowing at Smith Prairie may have contributed to the high forb presence found there during the investigation.

Live biomass and number of exotic species were similar to prairie remnants from the BP (Polley et al. 2005; Table 4), which were east of the site and also dominated by little bluestem but had different forb species. These forb species accounted for much of the diversity at Smith Prairie. Diversity at Smith Prairie in the GP was similar to that of remnants investigated in the BP (Polley et al. 2005; Table 4) but GP grasslands had a high diversity of perennial and annual forbs resulting in high species richness (Smeins 2004). Plants in Riesling and Temple prairies (Polley et al. 2007) in the BP had similarities to the GP remnant in this investigation. Temple Prairie remnant dominants from most to least dominant based on biomass included little bluestem, *Helianthus maximiliani* (Maxmillian sunflower), and *Elymus canadensis* (Canada wild rye) while the Riesel Prairie remnant was dominated by little bluestem, *Desmanthus*

illinoensis (Illinois bundleflower), *Arnoglossum plantagineum* (prairie plantain), and Indiangrass. Smith Prairie had little bluestem, prairie bishop, and Texas sage as dominants.

Mowing or the reestablishment of grazing in anthropogenically stressed grasslands can enhance biodiversity (Collins et al. 1998). Frequent mowing has likely changed biodiversity of Smith Prairie. In treatment plots that were mowed weekly for either one or two growing seasons, and control plots that were unmowed, Williams et al. (2007) found that forbs in mowed plots had significantly greater root and shoot mass than those in control plots in the first and second growing seasons but were not significantly more abundant. However, by the fourth growing season, forbs were twice as abundant in the mowed treatments and there were no lasting negative impacts of frequent mowing on the grass population observed (Williams et al. 2007). Tälle et al. (2018) found mowing effects were site-specific, differing between site and study conditions.

In summary, the composition of Smith Prairie is similar to other prairies reported on through time with the exception of high forb composition, usually caused by grazing, but likely influenced by mowing in the case of Smith Prairie. The prairie remnant was comprised of two vegetational layers: 1) upper-canopy, mainly along an intermittent stream and consisting of a few scattered shrubs and trees including sugarberry, Ashe's juniper, and honey mesquite. 2) open areas containing annual and perennial forbs and grasses. The most important forbs were prairie bishop and Texas sage. These two forbs were found in other prairie descriptions but were never listed as dominants. The most important grass was little bluestem, which is commonly described as the dominant grass in north Texas prairies. Prairie bishop, which is an annual forb, was common in the spring but did not occur in the other seasons. Texas sage and little bluestem, both perennials, were common in all three growing seasons. Dyksterhuis (1946) described a *Schizachyrium* type for the Fort Worth Prairie and our results were generally similar to his, for Smith Prairie. Live biomass, diversity, and number of exotic species were similar to prairie remnants from the BP, east of our site, which were also dominated by little bluestem, but had different forb species.

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Survival and mortality of protected and non-protected *Juniperus ashei* seedlings in Central Texas juniper/live oak woodlands

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ABSTRACT

Juniperus ashei is a dominant woody species in many Central Texas woodlands on the Edwards Plateau. It readily encroaches into disturbed grasslands. Past studies of one cohort of *J. ashei* seedlings below a *J. ashei* canopy projected extinction in 35 y with none reaching the canopy. However, effects of herbivory have not been examined previously. Mortality of *J. ashei* seedlings protected from herbivory (caged) or not protected (not caged) was investigated. The study site was in the Albert and Bessie Kronkosky State Natural Area (under development) in the Central Texas Edwards Plateau physiographic region (N 29.74619°, W 98.83573°). Treatments compared 50 caged *J. ashei* seedlings and 50 non-caged seedlings. All *Juniperus ashei* seedlings had just emerged and were selected arbitrarily from the *J. ashei* understory. Cages were cylindrical, 30 cm tall and 15 cm wide, constructed of 1.3 cm galvanized hardware cloth, anchored with rebar. The seedlings were counted bi-weekly the first growing season then annually. Seedlings with any green foliage present were considered alive. Three caged seedlings and four non-caged seedlings died in year one (2019). There was no significant difference in mortality between caged and non-caged seedlings in year one ($X^2=0.154$, $P > 0.05$). Mortality continued through year five of the study linearly with no significant difference between treatments. Mortality was 50 % (25 plants) for protected juveniles and 58 % (29 plants) for non-protected juveniles at the end of the fifth growing season ($X^2=0.644$, $P = 0.422$). Herbivory is not important for juvenile *J. ashei* survival. Published online www.phytologia.org *Phytologia* 105(3): 84-90 (December 21, 2023). ISSN 030319430.

KEY WORDS: herbivory, caged plants, non-caged plants, survival, replacement, recruitment, lack of recruitment, Edwards Plateau

Species recruitment is controlled by biotic and abiotic factors or a combination of both (Keddy 2017; Begon and Townsend 2021). Common as well as rare species are affected similarly (Falk et al. 1996; Poole et al. 2007; Nelson-Dickerson and Van Auken 2016; Van Auken et al. 2022, 2023). Factors could include water availability, other soil resources, light levels, herbivory, and a species' competitive abilities. Controlling factors can have positive, negative or mixed effects on a given species. Herbivore browsing can be detrimental and a major contributor to seedling mortality and lack of recruitment (Ameztegui and Coll 2015; Van Auken et al. 2022, 2123). *Juniperus ashei* seedlings have been shown to survive for 35 years beneath *J. ashei* cover, but none reached the canopy (Van Auken et al. 2004). Although *J. ashei* is a dominant woody plant in many Central Texas Edwards Plateau woodlands communities, there is some recruitment in open areas associated with the woodland canopies (McKinley and Van Auken 2005; Van Auken et al. 2023). However, the importance of herbivory to recruitment of juvenile *J. ashei* plants has not been examined.

There are other woody species found in these Edwards Plateau woodlands (Van Auken 2008). Some of the other woody species include *Diospyros texana* (Texas persimmon), *Prosopis glandulosa* (honey mesquite), *Sephora secundiflora* (mountain laurel), *Acer grandidentatum* (bigtooth maple), *Quercus lacyi* (Lacy oak), *Q. muehlenbergii* (chinkapin oak), *Juglans major* (Texas black walnut), and others (Van Auken et al. 2022). Many juveniles of these species are present in the understory of these communities with little

or no recruitment into the overstory (Van Auken et al. 2023).

Juniperus ashei seedling mortality is related to multiple variables, including temperature, rainfall, canopy cover, soil moisture, and light availability (Jackson and Van Auken 1997; Van Auken et al. 2004; McKinley and Van Auken 2005). In addition, fire and herbivory are important for recruitment of many species (Collins and Wallace 1990; Cote et al. 2004; Andruk et al. 2014). Previous studies demonstrated that *J. ashei* seedling emergence was greatest one to four months after higher rainfall during the coldest months (Van Auken et al. 2004) and most mortalities occurred during months that were hot and dry (Jackson and Van Auken 1997). Lowest mortality was in the *J. ashei* understory (Jackson and Van Auken 1997). Seedling mortality was approximately 8% per year, but the cause of mortality was not determined (Van Auken et al. 2004). Some have examined effects of herbivory on different *Juniperus* species (Cadenasso et al. 2002), while herbivory of mature *J. ashei* has been observed (Armstrong and Young 2002; Bryant et al. 1981; Warren 1983), it was a minor part of the ungulates diet and apparently did not include juveniles.

The relationship between large herbivores and *J. ashei* seedling mortality is inferred but not well studied. Most of the *J. ashei* herbivory studies look at *Odocoileus virginianus* (white-tailed deer) as the main herbivore (Armstrong and Young 2002). *Juniperus ashei* is infrequently browsed, and *O. virginianus* prefer other species including various *Quercus* spp., *Ulmus* spp. (elm), *Celtis* spp. (hackberry), and *Eysenhardtia texana* (Texas kidneywood). *Juniperus ashei* browsing is an indicator of poor range conditions and low availability of more favorable forage (Armstrong and Young 2002). *Juniperus* foliage and mast in a range with poor conditions (Bryant et al. 1981) was between 17-26% (Warren 1983).

The purpose of this study was to examine survival and mortality of *J. ashei* seedling that were protected from herbivory caused by large herbivores (caged) or unprotected, in the open (non-caged).

MATERIALS AND METHODS

This study was conducted on the Albert and Bessie Kronkosky State Natural Area (ABK, under development, not open to the public) approximately 14 km west of Boerne, Texas, within the Edwards Plateau Physiographic Region (Fig. 1). The natural area is approximately 1500 ha. The study site was below a mature *J. ashei* canopy (29.74589°N, 98.83710°W). The elevation was approximately 470 m above sea level. The mean annual temperature was approximately 18.94 °C, and the mean annual precipitation was approximately 79.35 cm with considerable variability (NOAA 2019). The soil type is a mixture of the Krum and Pratley series. The Krum series formed in clayey limestone alluvium. The Pratley series formed as a pedisegment from limestone bedrock (Soil Survey Staff 2014). The Edwards Plateau region of Texas has one of the highest populations of *Odocoileus virginianus* (white-tailed deer) in North America (Russell et al. 2001; Russell and Fowler 2004; Van Auken 2018), but the natural area is high fenced with a reduction in the *O. virginianus* population (Carpenter and Brandimarte 2014).

Finding and identifying *J. ashei* seedlings was carried out from May-July 2019. Seedlings were selected arbitrarily from the *J. ashei* understory for inclusion in the study with an example of a living and dead seedling in Fig. 2. All seedlings were current year germinates with cotyledons (two opposite, long seed leaves). Sample seedlings were tagged with 3 cm round stainless-steel tags numbered 1 through 100. The tags were secured with 15 cm long, 0.2 cm diameter, galvanized steel garden staples.

The exclosures were constructed using 1.3 cm galvanized hardware cloth and 0.1 cm galvanized steel wire and some of the exclosures below the canopy are shown in Fig. 3. The hardware-cloth was cut into 30 x 47 cm rectangles, rolled into a 30 cm tall cylinder, and edges were secured with 3 pieces of 8 cm long wire. The hardware cloth was also cut into 18 cm by 18 cm squares to secure the top of the cylinders. The exclosures were installed over 50 seedlings (tagged with even numbers) and secured to the ground with

3 pieces of approximately 1 cm by 61 cm rebar. All of the seedlings (protected and non-protected) were observed biweekly from July 2019 through November 2019 of the first growing season. After the first year they were examined annually in late summer. A seedling was considered alive if any green foliage was present. A chi-squared test was performed to compare the seedling mortality between the caged and non-caged treatments.

On November 19, 2019, at mid-day, light levels were measured using a FieldScout Quantum Light Monitor 3415F. Twenty light measurements were made in an open area with ambient light, in addition to 20 measurements made adjacent to 20 samples in cages and 20 in the open (no cage) all in the *J. ashei* understory. A one-way analysis of variance (ANOVA) and Tukey-Kramer Multiple Range Test were used to compare the mean light levels between the understory caged and non-caged, plants as well as open ambient light measurements. In addition, number of surviving plants or mortalities in various treatments at various times were examined with non-parametric X^2 analyses in JMP Pro 16.

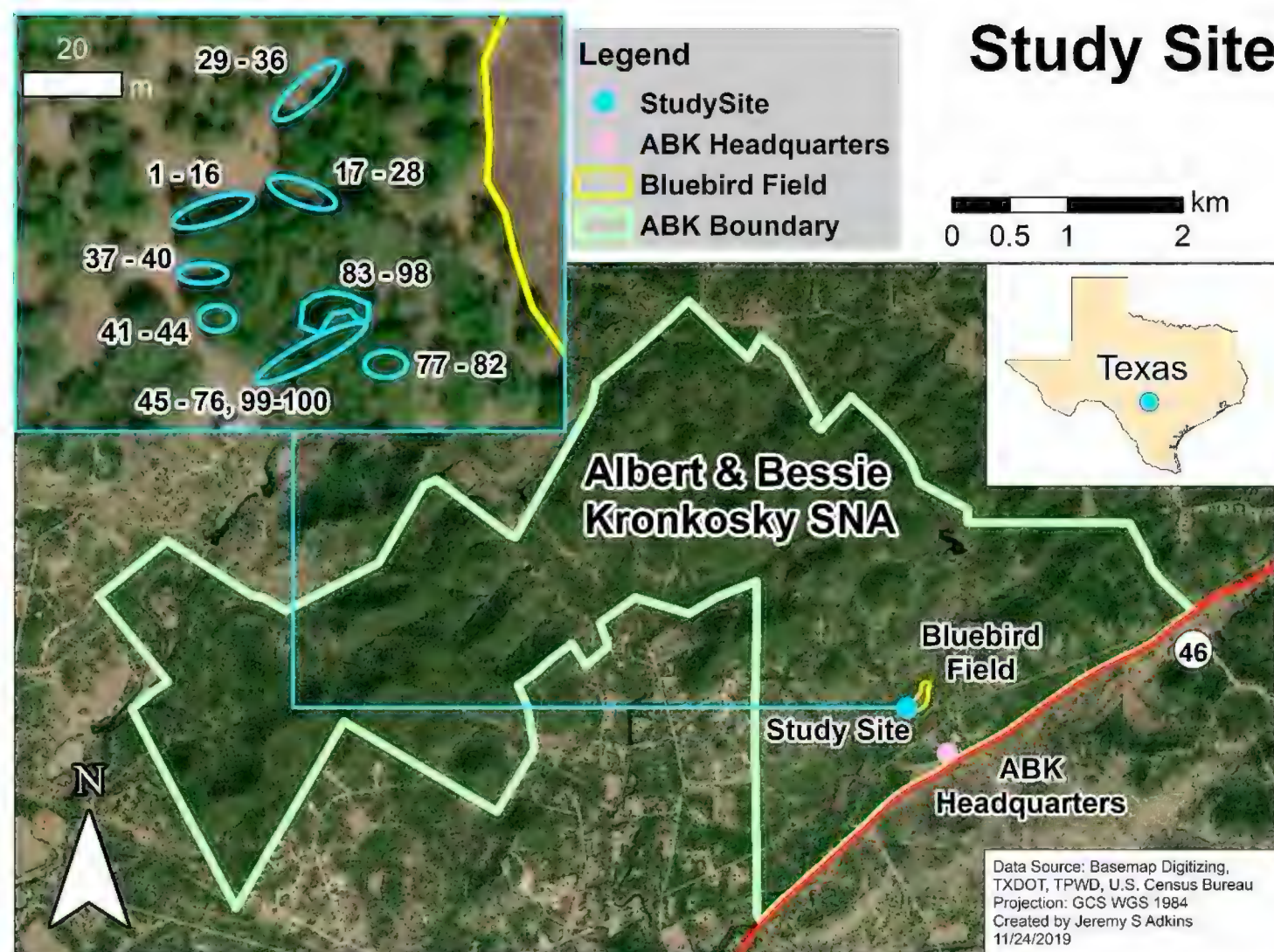


Figure 1. Map of the study site showing the approximate location in Texas (upper right) and in The Albert and Bessie Kronkosky State Natural Area (lower right). The natural area boundary and the approximate distribution of seedling samples throughout the study site. The natural area is located along Texas State Highway 46 in Bandera and Kendall Counties (lower right). The study site is in Bandera County.



Figure 2. Comparison of a live *Juniperus ashei* seedling (A) and a dead *J. ashei* seedling (B). A seedling was considered alive if any green tissue was present.



Figure 3. *Juniperus ashei* understory showing seedling exclosures (with seedlings), and the shade variability present in parts of the study area.

RESULTS

At the end of the first growing season (November 2019) 47 protected *J. ashei* seedlings were alive (3 dead), and 46 unprotected, open (non-caged) *J. ashei* seedlings were alive (4 dead). There was no significant difference between treatments ($X^2=0.154$, $P > 0.05$). All mortalities occurred during the summer of the first year (Fig. 4A and B).

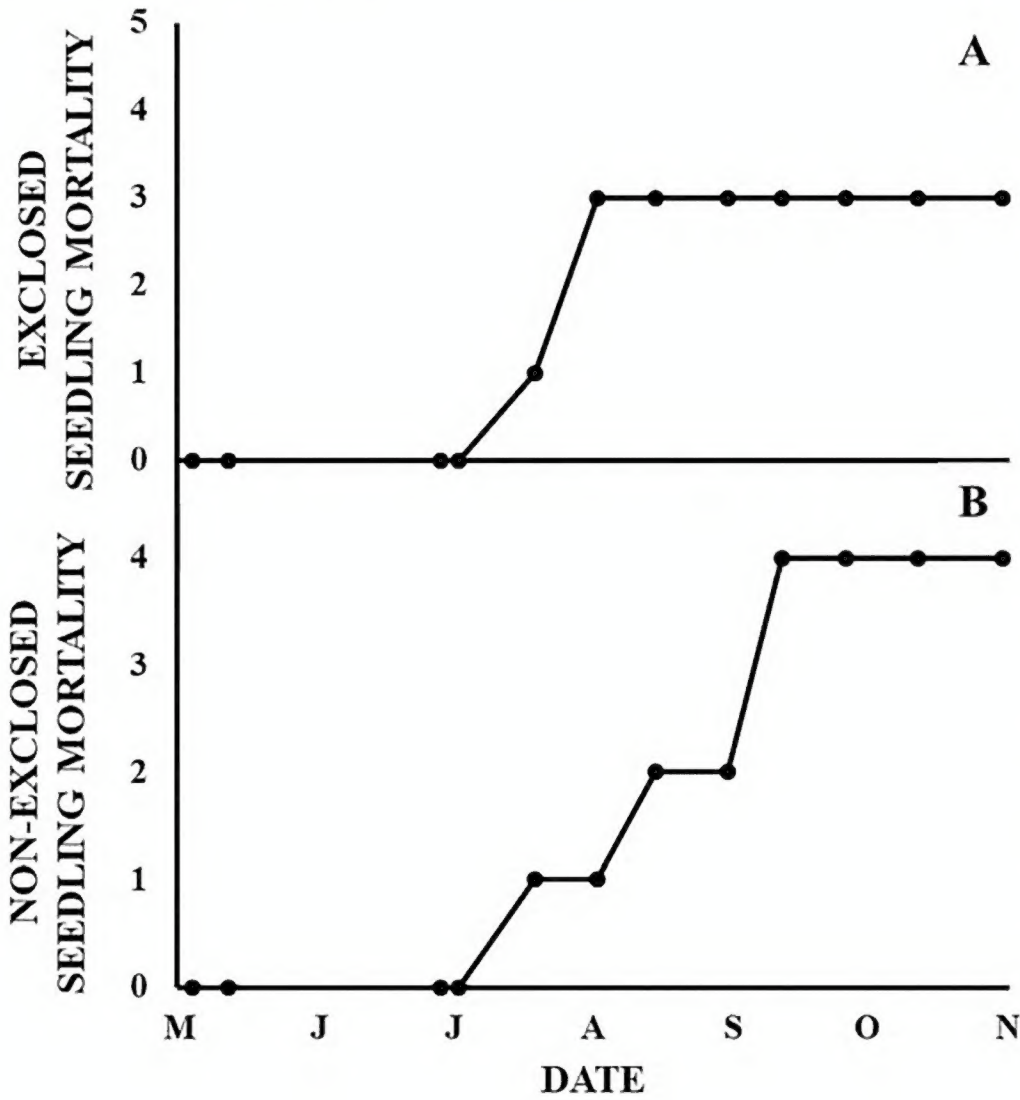


Figure 4. Seedling mortality of *Juniperus ashei* seedlings at Albert and Bessie Kronkosky State Natural Area between May 23, 2019 and November 19, 2019. (A) Of the 50 tagged and caged *J. ashei* seedlings, 3 died. (B) Of the 50 tagged and non-caged *J. ashei* seedlings, 4 died. There is no difference between caged and non-caged seedlings ($X^2=0.154$, $P > 0.05$).

The mean light level was $198 \pm 323 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ for understory cage treatments and $329 \pm 383 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ for open, non-caged plants. The mean understory light level was $263 \pm 365 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ and in the open outside the canopy it was $1521 \pm 72 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ (November 19, 2019, Table 1). There was no significant difference between the mean understory caged versus non-caged treatments ($p>0.05$). There was a significant difference between the mean open ambient (no canopy) light levels and the mean understory light levels ($p<0.01$).

Seedling mortality continued to increase for protected and non-protected individuals through the fifth year of the study. For the open plants (non-caged) there were 29 total mortalities (58% of the total). While for the protected plants (caged) there were 25 total mortalities (50% of the total) with no significant differences (Fig. 5, $X^2=0.645$, $P = 0.422$). There were 21 survivors in the open and 25 in the protected treatments (Fig. 5). Most mortalities were in the last two years of the study (Fig. 5).

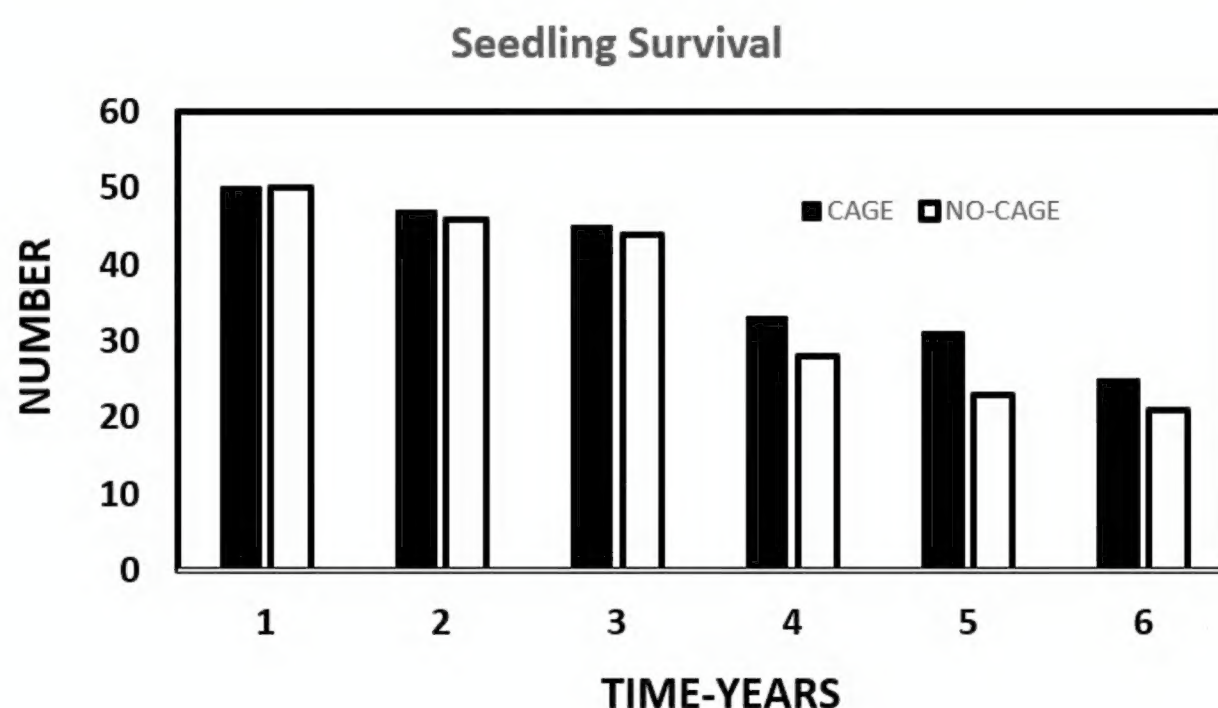


Figure 5. Survival of *Juniperus ashei* seedlings at Albert and Bessie Kronkosky State Natural Area from the beginning to the end of the study (September 2023). In the open (no-cage) there were 29 total mortalities while in the caged or protected treatment there were 25 mortalities. There was no difference in mortality between caged (protected) and non-caged (non-protected) treatments ($X^2=0.645$, $P = 0.422$).

DISCUSSION

Some studies examined the relationship between *Juniperus ashei* seedling mortality and multiple variables including light, rainfall, and soil moisture (Jackson and Van Auken 1997; Van Auken et al. 2004; McKinley and Van Auken 2005). However, most literature observations were antidotal concerning herbivory. That is, the studies did not have protected plants. *Juniperus ashei* and other *Juniperus* herbivory studies showing some browsing of mature individuals (Bryant et al. 1981; Warren 1983; Fuhlendorf et al. 1997; Armstrong and Young 2002; Cadenasso et al. 2002;). Recruitment of seedlings of *J. ashei* into the mature or adult population has been demonstrated (Van Auken et al. 2023) but was occurring in open, disturbed areas adjacent to mature canopy trees. *Juniperus ashei* seedlings may be more palatable than mature leaves and branches, but has not yet been demonstrated. Identifying the relationship between *J. ashei* seedling mortality and large mammal herbivory will contribute to the understanding of *J. ashei* growth development and may influence *J. ashei* management.

In this study, *Juniperus ashei* seedlings were observed for differences in mortality of those protected from herbivory (caged) or not protected (not caged). There was no apparent difference between those protected from herbivory or not protected. *Juniperus ashei* composes a small portion of *O. virginianus*

browsing (Bryant et al. 1981; Warren 1983). This observation may indicate potential *J. ashei* seedling browsing if the range conditions are poor. One of the studies demonstrated that browsed *J. ashei* foliage was less digestible than other browsed samples (Adams et al. 2013). *Juniperus ashei* seedling digestibility measures may help clarify if seedlings are more palatable than leaves of mature trees. An example of when *J. ashei* seedlings may be favored over mature *J. ashei* trees is when there is no mature green foliage below the browse line. In another study observing *J. ashei* seedlings, stated that there was little to no apparent seedling mortality related to deer herbivory (Jackson and Van Auken 1997). That study was conducted at Eisenhower Park in a more urbanized region with fewer *O. virginianus*.

The current study site may be limited because the natural area has managed wildlife populations. There may be different results in an area with a higher population density of *O. virginianus* or other large herbivores, such as *Odocoileus hemionus* (mule deer), or exotic game species such as *Axis axis* (axis) and *Oryx dammah* (oryx), or possibly domestic goats (Bovidae, *Capra* sp. that have been used for range improvement by removing woody vegetation including juvenile *Juniperus* plants [Scifres 1980]). However, there were no goats in the ABK State Natural Area. Future studies should observe additional cohorts in other sites with different environmental characteristics and properties. The current study contributes to understanding the relationship between *J. ashei* seedlings recruitment and herbivory and to the understanding of community dynamics.

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